METALLURGIA

THE BRITISH JOURNAL OF METALS.

JANUARY, 1932. VOL. V., No. 27.

Research Laboratories

It is due to the efforts of research workers in all branches of scientific investigation that progress is being maintained in establishing ascendency over disease, in the production of food necessary, in economising motive power, in reducing the limitations of the products capable of being obtained from the raw materials of the world, and in cheapening production.

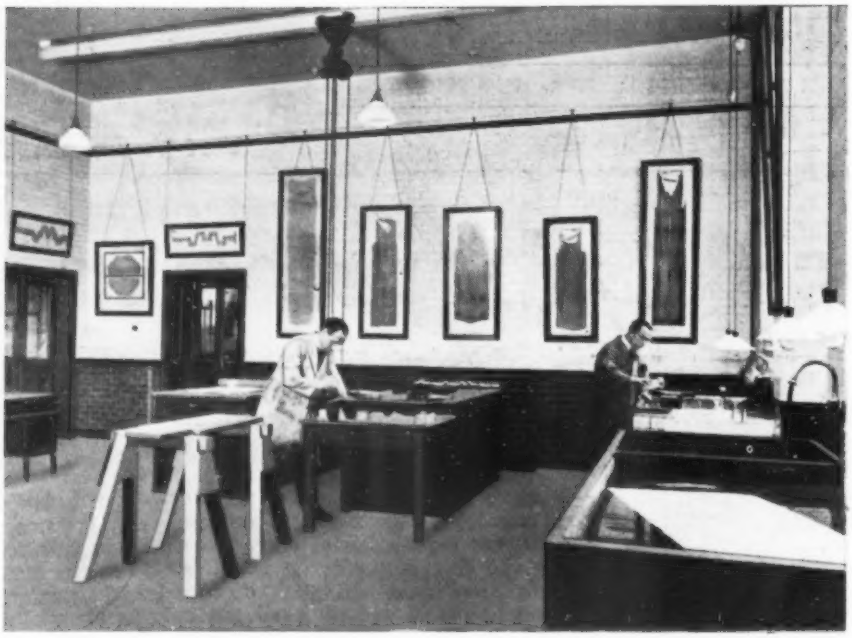
THE gulf that formerly existed between scientific knowledge and its application to the needs of civilisation has gradually narrowed until to-day it is generally appreciated that progress is dependent upon ability to apply scientific knowledge effectively. The rate of progress is necessarily variable, because additions to the store of knowledge, or the use to which it is put, varies from time to time, but the totality of knowledge is ever on the increase. Science has revealed that everything in the world has special potentialities, of which we may avail ourselves as the need arises, but only in so far as we apply scientific knowledge successfully. It is the more general absorption of this knowledge that is gradually changing the world in which we live by making us more fully acquainted with the properties and potentialities of what is found in it.

The provision of the essential requirements for an ever-increasing population presents problems that can only be solved by persistent research to mitigate the effects of disease and to facilitate production, and all the various sections of research are concerned in the general advancement involved. Although the past century has given birth to many remarkable discoveries, development, on the whole, is gradual because of the need of increased scientific knowledge to perfect and widen the scope of these discoveries. Research is therefore necessary in order that advances may be made in stages that are more rapidly absorbed by mankind. Some discoveries are in advance of progress to such an extent that they may be partially or wholly forgotten; others, on the other hand, are so much needed that little time separates them from application.

This laboratory is reserved for the analysis of ferro-alloys, non-ferrous alloys, sand, refractories, and furnace slags, the examination of service materials such as oil, and non-routine estimations.

In much progressive work of this nature, particularly that associated with industry, economic considerations demand the exploration of every avenue likely to give better and cheaper products. It is for this reason that manufacturers appreciate the need of special laboratories, adequately staffed and equipped, not only to materially assist in maintaining the normal standard of their products, but in developing new products and revising the technique of production. The extended metallurgical and research department of the English Steel Corporation, recently officially opened by Sir Joseph J. Thomson, O.M., F.R.S., is an important example of the close connection now existing between scientific knowledge and industry.

These extensions and consequent reorganisation of the research laboratories is the natural culmination of the rationalising scheme which linked up the steel interests of Vickers, Ltd., at Sheffield, with those of Armstrong-Whitworth, at Openshaw, Manchester, and, later, those of Cammell Laird at Sheffield and Penistone. Since the inauguration of the major scheme, each of the companies concerned had maintained chemical and metallurgical laboratories. Naturally, there was much similarity in the work done, and even overlapping in the metallurgical problems under investigation, but, in addition to speciality manufactures, each had evolved a distinctive character, and these circumstances obviously presented difficulties in centralising the research laboratories of the group at a selected works. After careful consideration, however, it was ultimately decided to enlarge the existing metallurgical research laboratories at Vickers Works, Sheffield, in order to accommodate the merged staffs, leaving adequate scientific staff and equipment at the other works for



This laboratory is devoted to the examination of full-size sections prepared from ingots, forgings, castings, etc. The " sulphur printing," etching, and " nature printing " carried out in this laboratory reveal the general internal structure, segregation, and soundness within a large mass of steel.

dealing with the routine work of analysing and testing, and for investigating operating plant and manufacturing problems that could be carried out more successfully at the individual works.

This metallurgical and research department has now been completely organised, and the whole of the research resources concentrated without any loss of individuality or interference in the freshness of outlook of the research workers, who have been brought into closer collaboration.

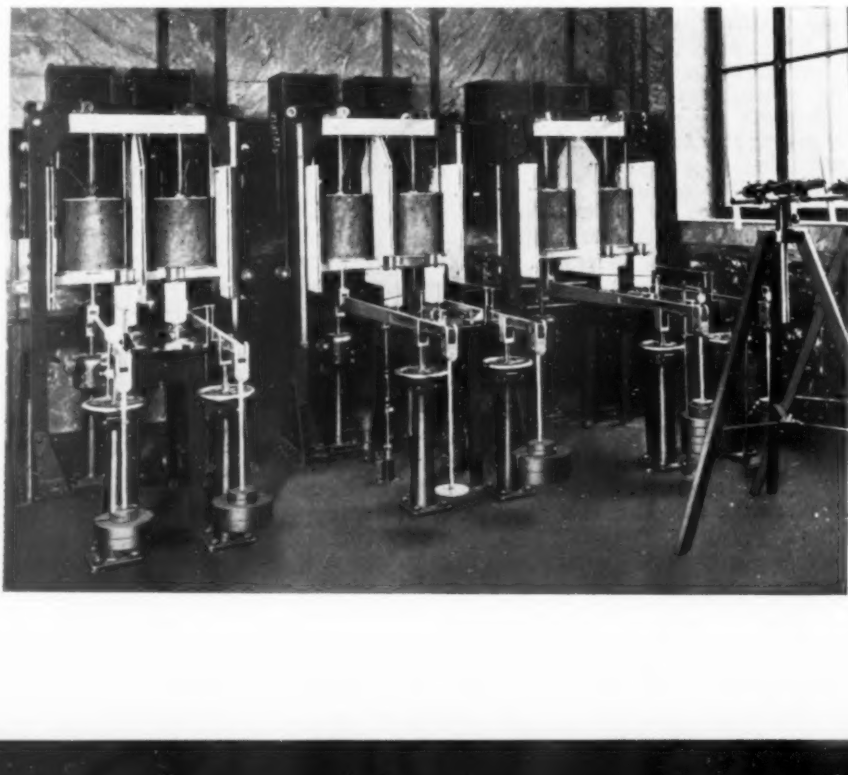
Metallurgical research is an attempt to approach ideal conditions as closely as possible within the limitations set by economic and other practical considerations. It involves a continual correlation between cause and effect—that is, between physical structure and chemical composition, on the one hand, and function on the other, so that the ideal structure and composition may be selected for a given function in the minimum of time. But modern industrial research has an increasingly widening significance: particularly is this true at the laboratories of the English Steel Corporation, a selected few of which are shown in the accompanying illustrations.

To understand the scope of of work embraced by this research department, it is necessary to refer briefly to its functions. Primarily, its purpose is to study, observe, and, when necessary, to supervise all metallurgical operations carried out within the several works of the Corporation, but other important functions are incorporated in the duties of this department. It will advise the manufacturing, estimating, and sales departments on technical problems regarding metallurgical processes, properties of materials, and the selection of steels for specific purposes; metallographic investigations of materials in course of production, or of parts returned from service for " post-mortem " examination, when either good or inferior performance demands; determine any chemical analysis of raw materials, or of steel in course of manufacture, required either for purposes of control, selection, or investigation; determine or collect thermal, physical, mechanical, or other data required for the information of manufacturing departments, the service of customers, or the progress of research; and generally carry out research and investigation relating to the manufacture, properties, and improvement of steels.

To perform these functions efficiently, the department has been divided into four main sections—viz., chemical analysis, works observation, metallographic, and research sections.

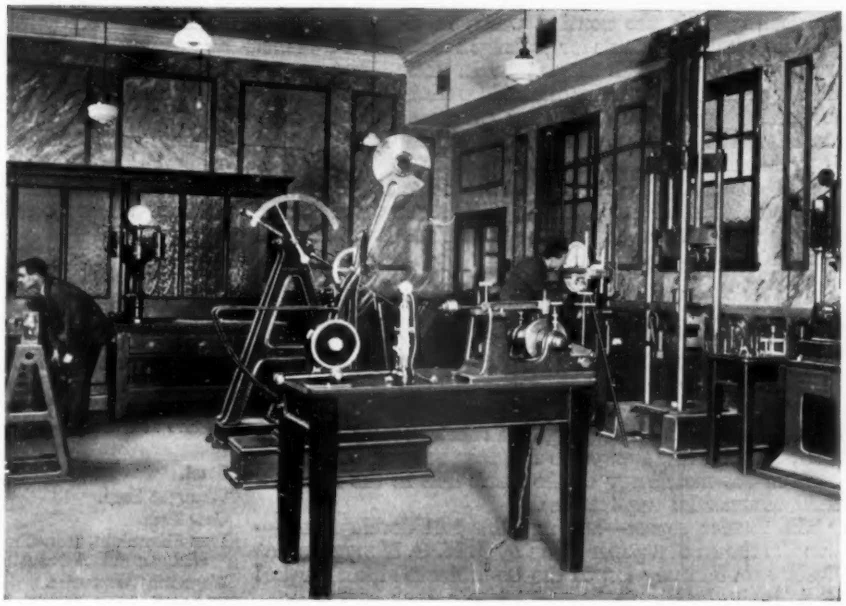
The function of the chemical analysis section is to determine the composition and purity of materials and products. Chemical analysis is indispensable in metallurgical work, and more particularly in steel manufacture, in which composition has so much influence on the structure and subsequent properties. The works observation section of the department serves as a link between the research laboratories and the various works, and has been created to bridge a gap which in many works frequently exists between the two, to the infinite disadvantage of both. The staff of this section are all trained metallurgists who keep in constant contact with the investigations of the department, and their duty is to apply in the works the results of investigations and researches, completed or in

Pioneer investigations into the phenomenon of " flow " or " creep " of heated steel under stress were carried out in this laboratory. Each of the six units below is designed to maintain a tensile test-piece for indefinite periods, of months in some cases, at elevated temperatures within a range of 1° C., while the extensometers can detect " flow " or " creep " of the order of one two-millionth of an inch, or a " creep-rate " of one hundredth-millionth of an inch per inch per hour.



progress, to extend scientific ideas and methods, to study existing processes, and to develop new ones, and generally by observation and study to effect improvements both in processes and products, as well as to detect and eliminate the causes of defects in materials.

The metallographic section is naturally greatly concerned with research work proper, but it is also involved in examinations of a routine character. Although control work of this kind, apart from research, is of somewhat recent development, it has become essential to the satisfactory production of special steels, particularly in the form of large forgings, as the assistance provided by the macroscopic examination of large "etched" sections, the taking of sulphur prints, and the use of the microscope are now indispensable. The object is to avoid the loss of finished material and to check and improve steel-making processes, and to meet requirements frequently specified. In addition to control examinations and research work proper, the metallographic section carries out the "post-mortem" examination of any steel part returned by a customer who desires to know the cause of a failure in service, or of an unusually good performance.



This laboratory is equipped with a variety of machines for making very accurate measurements of the strength of materials, both under "static" and "dynamic" conditions of testing.

The activities of the research section are naturally very varied. They cover the whole of the range of products of the Corporation. Much of the work done in this section is necessarily concerned with current manufacturing problems requiring more detailed or systematic investigation than is found possible by the routine metallographic staff. Similarly, occasional material failures may demand, or suggest, more fundamental research than is necessary in an ordinary post-mortem examination, and this sometimes leads to the discovery of some previously unknown property or behaviour of steel. Apart from work of this kind, arising out of current problems, more general systematic researches are continually in progress, among which may be cited those on the internal constitution and improved homogeneity of steel ingots, large and small, the effect of variation of composition and heat-treatment on the mechanical and other physical properties of steels, on the general phenomena of corrosion, on heat-resisting steels, on permanent magnets—not only as regards improved magnetic properties, but also in design, and, amongst many other subjects, on the phenomenon of the "creep" or "flow" of steels under continued load at elevated temperatures. In regard to the last-mentioned branch of research, so important in connection with the trend towards higher steam temperatures, it may be permissible to mention that the first published results of very prolonged tensile tests at elevated temperatures were of tests carried out in these laboratories. Finally may be mentioned the more highly specialised investigations, such as on armour plates, "bullet-proof" plate and gun forgings, which are necessary for the improvement of the armament products of the Corporation.

The physics laboratory is equipped for the preparation of heating and cooling curves and the determination of critical points, for measurements of electrical resistance, of magnetic properties in magnetising fields up to 3,000 gauss, of thermal expansion up to 1,000° C., and of thermal conductivity up to 400° C.

When it is appreciated that this metallurgical and research department is one of many associated directly with works in Sheffield and elsewhere, it will be recognised how much concentrated effort and scientific knowledge are required to meet the rapidly expanding fields of activity in which steel plays so important a part: particularly is true of corrosion and heat-resisting steels. Rapid development in various branches of engineering has only been possible as a result of the successful application of valuable research work on steel manufacture.

While the majority of large works are now equipped with laboratories adequately staffed

for dealing with the routine work, in many instances facilities are not available for prolonged research. Problems are frequently of such magnitude in their effect on an industry that the necessary scientific work involved cannot be carried out by an industry unaided. Under such conditions the State has an interest in assisting the solution of problems and valuable research work of this kind is carried on at the National Physical Laboratory and at Woolwich Research Department, while much valuable and disinterested research work is undertaken at the Universities.

RECENT DEVELOPMENTS IN CORROSION RESISTING STEELS.

CORROSION-RESISTING steels, as they are understood to-day, have been an article of commerce for rather less than twenty years. For the first six or eight years of this period progress in their development was slow, but the last few years has seen remarkable strides both in the metallurgy of the steels and in the range of their commercial applications.

The former aspect—*i.e.*, metallurgical developments—was the theme of a paper given by J. H. G. Monypenny at Dudley on January 12, to the Co-ordinated Metallurgical Societies in the Birmingham district.

The developments considered were grouped under three headings, namely :—

(1) The properties and uses of steels containing substantially greater amounts of chromium than were present in the ordinary hardenable (12/14% chromium) stainless steels.

(2) The production of austenitic stainless steels relatively free from the dangerous form of intergranular attack which was found in the earlier steels of this type.

(3) The production of complex alloys having special resistance to severely corrosive attack.

As regards high-chromium steels, the marked change in properties which is observable as the chromium content rises above about 14% was shown to be due to the action of chromium on the range of existence of Y-iron, and details were given of the structural characteristics and properties of these high-chromium steels as affected by carbon content and by heat-treatment. Their mechanical properties were poor, and they were only slightly susceptible to heat-treatment unless their carbon content was raised to such an extent as practically to nullify the benefits (from a corrosion-resistance point of view) of their higher chromium content.

Addition of nickel to the low-carbon steels of this type, however, increased very markedly their hardening power. The gradual change in the structural characteristics of a 17/18% chromium steel brought about by the addition of nickel, in various amounts up to 12%, was described. Steels containing about 2% nickel were shown to have very good mechanical properties, and they had found many applications, for example, in the construction of aircraft. Raising the nickel content to about 5% produced steels which could be hardened and tempered or made austenitic depending on heat-treatment conditions. They were also interesting in that, when austenitic, they were appreciably hardened by being cooled to very low temperatures—*e.g.*, by immersion in liquid. The commercial utilisation of such steels, however, was likely to be very difficult, as they were not easily machined.

As regards the austenitic steels, the occurrence of intergranular corrosion was shown to be due to the precipitation of a membrane of carbide at the austenite grain boundaries. Typical examples of its occurrence were described and also means of detecting its presence or the liability for its production in various steels. Methods for overcoming this serious defect had involved the lowering of the carbon content of the steel to 0·07% or less, or the addition of various alloying metals, such as tungsten, titanium, vanadium, and silicon. The effect of prior heat-treatment and of high nickel content or the development of the carbide membrane was also discussed.

As regards the third direction in which development had occurred—namely, the addition of other alloys for increasing the corrosion resistance of the austenitic steels against particularly corrosive chemicals, the effects of molybdenum, tungsten, copper and silicon, were briefly described. Molybdenum probably had the greatest effect, and as typical examples of its action, details were given of the behaviour of molybdenum, containing steels with sulphuric and other acids of various concentrations and at various temperatures.

1931 A.S.T.M. Proceedings.

Part I. of the 1931 A.S.T.M. *Proceedings* contains the annual reports of the Society committees and the papers and standards appended thereto. The President's annual address and the annual report of the Executive Committee are also included.

The reports of the standing, research, and sectional committees which function in the metals fields involve such subjects as the following :—

Ferrous Metals.

Steel.	Effect of Temperature on the Properties of Metals.
Wrought Iron.	Yield Point of Structural Steel.
Cast Iron.	Wrought-iron and Wrought-steel Pipe and Tubing.
Iron Chromium, Iron-Chromium Nickel and Related Alloys.	Corrosion of Iron and Steel.
Magnetic Properties.	Zinc Coating of Iron and Steel.
Magnetic Analysis.	Fatigue of Metals.

In this group there are also a number of extensive papers involving: Fatigue tests of low-carbon steel at elevated temperatures; low-temperature endurance testing; creep-testing apparatus; correlation of cast-iron test-bar and casting by volume-surface ratio; and bibliography on embrittlement of structural steel in galvanising.

Non-ferrous Metals.

Non-ferrous Metals and Alloys.	Die-cast Metals and Alloys.
Electrical-heating, Electrical-resistance and Electric furnace Alloys.	Light Metals and Alloys.
Copper and Copper Alloys.	Corrosion of Non-ferrous Metals and Alloys.

Appended papers discuss the effect of composition on aluminium-base die-casting alloys, and lead-base and tin-base alloys for die castings.

Committee reports involving non-metallic materials :—

Cement	Concrete and Concrete Aggregates.
Lime	Fire Tests of Materials.
Brick	Gypsum.
Refractories	Hollow Masonry Building Units.

Papers appended discuss concrete curing; pavement-core drilling practice; analysis of fresh concrete; determination of cement content of set concrete; and elastic properties of concrete.

Also included are reports of committees on :—

Preservative Coatings for Structural Materials.	Bituminous Waterproofing and Roofing Materials.
Petroleum Products and Lubricants.	Electrical Insulating Materials.
Road and Paving Materials.	Rubber Products.
Coal and Coke.	Textile Materials.
Timber.	Thermometers.
Classification of Coals.	Slate.
	Natural Building Stones.

In this group there are several extensive sub-committee reports and many proposed specifications. Appended subjects include stability tests on coke and psychrometric tables for relative humidity.

Other committee reports involve methods of testing, metallography, and nomenclature and definitions. The Committees on Papers and Publications, on Correlation of Research, and on Standards also have reports in Part I.

In order to give as complete a picture as possible of committee activities, the tentative standards which have been prepared by each committee and subsequently adopted as tentative by the Society are included in Part I. of *Proceedings*. Thus there are 74 tentative standards given, all of which have been adopted and published in 1931 for the first time. Several tentative revisions in standards are also included.

In this part of the 1931 *Proceedings* there are reports of 42 standing and research committees, and reports of one joint and two sectional committees. Part II. of the 1931 *Proceedings* contains the technical papers which were given at the annual meeting of the Society in June, 1931.

Each part of these Proceedings is available from the American Society of Testing Materials, 1345, Spruce Street, Philadelphia, Pa., U.S.A. Price $5.50 paper binding; $6.00, cloth binding; $7.00, half leather.

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The British Journal of Metals

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All the rates are subject to change without notice, according to appreciation or depreciation of the exchange.

Published Monthly by the Proprietors, THE KENNEDY PRESS LIMITED, at 21, Albion Street, Gaythorn, Manchester.

Telegrams : "Kenpred," Manchester. *Telephone : Central* 0098.

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THE BRITISH JOURNAL OF METALS.

1931-1932.

UNCERTAINTY rather than pessimism is the cloud that obscures the industrial outlook over the year that we have just entered. Seldom, if ever, during the last sixty years has the heavy iron and steel trade begun a year with more idle plant and fewer orders on the books. The chaotic condition of finance has disturbed the whole fabric of international trade, causing serious lack of credits abroad and a definite loss of confidence. It is primarily due to these depressing conditions that our staple industries are suffering unprecedented hardship. It is due to this state of affairs that there is the almost complete absence of shipbuilding orders, to mention only one of the important industries. In addition to the general depression nearly every nation has tended more and more to isolate itself behind high tariff walls, thereby curtailing the interchange of transport of goods, resulting in an unparalleled tonnage of shipping being laid up, with little inducement to place orders for new ships.

The former rapid movement of gold, with its attendant credit, has become stagnant in the bullion rooms of one or two national banks, and a large part of it is as little use as when it was still in the rock. Further, dislocation in trade has resulted from commodity prices falling too low; costs outside the industry have been unable to fall as quickly, with the result that few of our major industries are carrying on without loss.

In the competition with our neighbours for such world trade as is obtainable, and even in our home trade, we start the New Year heavily handicapped. Our taxation *per capita*, and impositions for social service, have been by far the greatest in the world, while our wages in the iron and steel trades have been higher than those of our European competitors. With the balancing of the Budget in doubt, there would appear to be little hope of help as far as taxation is concerned, but the effect of the destandardising of the pound sterling is gradually becoming appreciable. Whether this will restore the balance in trade we very much doubt, and it is not improbable that new tariffs proposals will come into operation before the next Budget. The Parliamentary Secretary, Mr. Hore-Belisha, has visited many of the large iron and steel works in order to prepare a report dealing with these industries. It is evident that the National Government appreciate the position of the iron and steel trades, and that some step will be taken to assist those trades to recover markets that formerly accepted our manufactures. Even under the present unfavourable conditions reorganisation is in progress, and much new equipment is being installed, but with more settled conditions, further progress in this direction will assuredly be effected because many feel that additional costs at the moment are not warranted until the prospects are such as to give them a reasonable promise of a return for their expenditure.

Important as these prospects are for the resuscitation of the iron and steel trades, no hope of the return of normal trading facilities can be expected until world conditions are more settled and a feeling of confidence exists between the various nations. It is gratifying, therefore, that there are signs of a more rational international co-operation than has ever existed. This month it is hoped that some satisfactory solution of the reparations question and the reinstatement of Germany as a financially sound entity, may be brought about, with consequent confidence and goodwill.

A solution must be found to the problem of debts and reparations before any reasonable progress can be hoped for, and while we fear it is too bold to suggest that France should initiate a policy of wiping out debts and reparations at the Lausanne Conference, some compromise must be effected which will give Germany a reasonable chance to recover. Let the nations give her an extended moratorium, and we believe that the German people will strive to overcome their present difficulties and meet their obligations at the expiration of a reasonable time. Our own representatives at that Conference can do much: let them make the fullest declaration of the policy of the British Government in the plainest language possible, so that there may be no question of our goodwill towards all nations entangled in war debts and reparations.

The vital importance of a solution satisfactory to all is intensified by the fact that the Disarmament Conference meets at Geneva at the beginning of February, just a fortnight after the commencement of the conference at Lausanne. Thus the future of civilisation is linked up in an unmistakable way with the result of this month's conference. The nations must come to an amicable arrangement for any success to attend the deliberations of the Disarmament Conference.

At the present time the position in regard to armaments is remarkable. Some nations have been literally disarmed with the object of promoting peace; others, on the other hand, are armed in greater readiness for war than ever, also in the cause of peace. How can this position be reconciled with goodwill? There must be confidence and trust to acquire goodwill, and should the Disarmament Conference arrive at some practical results, the growth of goodwill should lead to a sane readjustment of trading between nations. In addition, large sums of money would be liberated for the replacement of machinery and other creative products.

Yet another conference of great importance to the future of industry is due to commence in June—that is, the Imperial Conference. This may be a somewhat narrow view to take, because the main interest Great Britain has in the Dominions is in their individual prosperity, but we believe that feeling is reciprocated, and there is ample scope for helpfulness on the part of each, so that the whole Empire may prosper. The prosperity of each Dominion is of vital importance to Great Britain, and it is equally true that the prosperity of Great Britain is linked up with each of the Dominions and Colonies. After all, it is perfectly sound reasoning that in exchange for wheat, wool, and other primary articles the Dominions and Colonies should be encouraged to accept our finished steel, coal, and such goods as we are able to produce more cheaply and better than they. In this way trade might well be stimulated, even if, owing to continued disorganisation of the currency, it is necessary to resort to some form of national bartering.

It must not be assumed that we agree with absurd suggestions sometimes made that the Dominions should confine themselves to raw materials. They have a perfect right to develop their own industries, and the representatives of Great Britain will be the last to hinder that development, but they can quite well offer the services of this country to assist in that development. Given the proper

spirit of co-operation, there can be no doubt that British industries will benefit to an increasing extent as developments of the Dominions proceed. Since this country always provides a ready market for produce from the Dominions, co-operation will lead to a fuller degree of reciprocation and wider trading facilities.

For the rest, Russia, China, Central Africa, South America, and other large regions of the earth, must, for many years to come, provide extensive markets for goods and manufactures that Great Britain can supply, if only peace and co-operation between nations can be made certain.

In our own country, though we have much very fine and up-to-date plant, which, in point of efficiency, is equal to the best in the world, there is a great deal waiting to be scrapped as soon as there appears to be a likelihood of new plant earning its cost. All this will require iron, steel, and coal. The demand for our goods, so long as they are the best, undoubtedly remains and only awaits a change to greater confidence to be expressed. It is on the obtaining of this confidence that the outlook for 1932 depends.

The outlook is certainly brighter, because political and world conditions cannot remain as they are. The nations must get together in a proper spirit of co-operation, with the primary object of removing uncertainty, distrust, and apprehension, which are a menace to progress, and promoting goodwill. We are optimistic in regard to the results of the various conferences, and for this reason we believe the long-delayed industrial recovery will begin this year. No sudden boom is anticipated, but a steady improvement will, we believe, result from the beneficial effects of the international deliberations which should not fail to promote the spirit of reconciliation and subsequent goodwill and peace amongst nations.

Aviation Developments.

CONSIDERABLE developments are likely to take place this year in British aviation. Many ambitious schemes are being planned with the object of increasing the high prestige this country has already earned in aircraft construction. One of these schemes is the establishment of a regular Transatlantic service, and for this purpose a very large flying-boat is being built for the British Government at Southampton. Weighing 35 tons, and capable of carrying 40 passengers, in addition to the crew, this monoplane is designed to fly continuously for about twelve hours at an average speed of 120 miles per hour. It is being constructed primarily for service on the British section of the proposed Transatlantic mail route.

An outstanding event in aviation will be the opening of the Imperial Airways air route to Capetown, which will be inaugurated on January 20. Although the schedule allows eleven days for this flight, it is fully expected that, after operating experience has been gained, this timetable will be reduced to nine days. A weekly air-mail service is the object, and it will have a considerable influence in speeding-up business.

Ambitious plans are in progress for a double Transatlantic flight in the spring. Mr. J. A. Mollison, Colonel Fitzmaurice, and Captain Saul, who are making these arrangements, are expected to make the double trip in the machine used by the late Commander Glen Kidston.

Amongst other important projects, the attack on the world's non-stop long-distance air record is not the least; this is being made by the Air Ministry, and with the object of flying to Capetown without alighting, a Fairey long-range monoplane will leave Cranwell Aerodrome about February 19. This flight is expected to take about sixty hours. These and other schemes, which, on maturing, show the degree of perfection in British aircraft design, have a considerable influence in maintaining the confidence of foreign countries in the aircraft made in this country, and indirectly assists the export trade in British machines.

Forthcoming Meetings

INSTITUTION OF MECHANICAL ENGINEERS.

Jan. 29. General Meeting. "The Mechanism of Electric Locomotives," by J. D. Twinberrow, M.I.Mech.E.

Graduates Section (London).

Jan. 25. "Locomotive Testing and Research," by J. Bell.

Jan. 30. Reception and Conversazione.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

Jan. 29. "Modern Dutch Yard Arrangement and Practice," by A. Van Donkelaar.

Feb. 12. "The Prevention and Insulation of Noise," by E. G. Richardson, B.A., Ph.D., D.Sc.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.

Jan. 26. "The Air Resistance of Ships' Hulls and Superstructures," by G. Hughes, B.Sc.

INSTITUTE OF METALS.

BIRMINGHAM SECTION.

Jan. 21. "Electric Welding of Non-Ferrous Alloys," by A. Burstall, D.Sc.

Feb. 4. "The Dilatometer in the Study of Steels," by N. P. Allen, M.Met.

LONDON SECTION.

Feb. 10. "Some Recent Advances in Protective Coatings on Metals," by M. Sutton, M.Sc. (Joint meeting with Electroplaters and Depositors Technical Society, at Northampton Polytechnic Institute.)

NORTH-EAST COAST SECTION.

Feb. 9. "Some Developments in Non-Ferrous Alloy Founding," by H. C. Dews. (Joint meeting with Newcastle branch Institute of British Foundrymen.)

SCOTTISH SECTION.

Feb. 8. "Aluminium Silicon Alloys—Their Properties and Some Applications," by R. B. Deeley, B.Sc., A.R.S.M.

SHEFFIELD SECTION.

Feb. 12. Discussion of Certain Zürich Meeting Papers.

INSTITUTE OF BRITISH FOUNDRYMEN.

BIRMINGHAM, COVENTRY AND WEST MIDLANDS BRANCH.

Feb. 4. "Modern Methods of Enamelling Cast Iron," by J. H. D. Bradshaw.

EAST MIDLANDS BRANCH.

Jan. 30. "Production of Ferrous and Non-Ferrous Castings for High-Class Internal Combustion Engines," by S. White (at Loughborough).

LINCOLNSHIRE SECTION.

Feb. 6. "The Effect of the Elements on Cast Iron and Its Properties," by A. E. Musgrave.

LANCASHIRE BRANCH.

Feb. 6. Annual Dinner. Grand Hotal, Manchester.

BURNLEY SECTION.

Feb. 12. "Black Sands," by B. Hird.

LONDON BRANCH.

Jan. 12. "The Practial Working of Rotary Pulverised Fuel-Fired Melting Furnaces," by W. Scott.

MIDDLESBROUGH BRANCH.

Feb. 12. "Some Aspects of Modern Foundry Practice," by F. Griffiths.

NEWCASTLE-ON-TYNE BRANCH.

Jan. 30. "Black Sand," by B. Hird.

Feb. 9. "Some Developments in Non-Ferrous Alloy Founding," by H. C. Dews.

SCOTTISH BRANCH.

Feb. 16. "Jobbing Moulding in a Jobbing Foundry," by A. Sutcliffe.

WALES AND MONMOUTH BRANCH.

Jan. 23. "The Facings Point of View," by H. Winterton.

Feb. 6. "Black Sand," by B. Hird.

WEST RIDING OF YORKSHIRE BRANCH.

Feb. 13. "Some Physcial Properties of Cast Iron," by H. W. Swift, M.A., D.Sc., M.I.Mech.E.

MANCHESTER METALLURGICAL SOCIETY.

Jan. 20. "Corrosion Fatigue of Metals," by Prof. B. P. Haigh.

Feb. 3. "Metals for Use at High Temperatures," by J. H. G. Monypenny, F.Inst. P.

INSTITUTION OF WELDING ENGINEERS.

Jan. 21. "Nickel and Its Non-Ferrous Alloys, with Special Reference to Welding," by J. McNeil (at the Institution of Mechanical Engineers).

Correspondence.

The Editor, METALLURGIA.

Chilled Iron Rolls.

Sir,—In your December issue, Dr. Anderson, in the interesting series of articles upon the rolling of aluminium, discusses the use of chilled iron and other rolls. Whilst Dr. Anderson reviews the question quite generally, it would seem that there are certain considerations not dealt with which should be taken into account.

Chilled iron rolls have been studied principally from the standpoint of rolling steel, which is probably the most refractory or unyielding material to be manipulated. Aluminium has a melting point of about 650° C., and is probaoly hot rolled between 550° and 600°.

Steel is nearly always finished above 750° C., and much steel is finished above 900°. So far as chilled iron rolls are concerned, therefore, the demands made upon the rolls, both thermally and mechanically, in rolling aluminium, must be much less than in rolling steel.

The question of the surface hardness of chilled rolls is controversial, but it is agreed that for heavy demands, such as tinplate rolling and thin steel generally, the lower the scleroscope figure, the better for durability in the roll. The scleroscope measurement of hardness is most useful if interpreted on broad lines. It is, moreover, agreed that temperature conditions in rolling steel have more to do with failure of the rolls than anything else.

Whilst, therefore, a high scleroscope test arouses some degree of suspicion in rolls for hot-rolling steel, on the grounds of risk of breakage, the same probably does not apply when the rolls are used for soft metals, like aluminium, apart from physical reasons of surface contact which may arise.

The precise depth of chill is also of less importance in aluminium rolling on both thermal and mechanical grounds. Probably, therefore, chilled iron rolls with a moderately high scleroscope test would have a life in service more than adequate in view of their relatively low cost, coupled with the ease with which these rolls are shaped to meet requirements, and this would apply both to hot and cold rolling.

In my opinion, nothing would be gained by insisting on a higher minimum scleroscope test than 63 for rolls employed to manipulate the softer metals.—Yours, etc.,

Sheffield. A. ALLISON.

White-Heart Malleable Iron.

AT a recent meeting of the Manchester Metallurgical Society the subject of "White-Heart Malleable Iron" was presented in a paper by Mr. C. Blades, of Leicester. He dealt with the matter chiefly from the foundry point of view, and explained that it was not so necessary to take elaborate precautions for melting as in the production of black-heart malleable iron. The range of permissible composition of the original iron was wider than in the case of the other form of malleable, and it was deemed advisable to keep the silicon content as low as under 0·5%, and phosphorus was best at a minimum, whereas it was possible to allow the sulphur content to range from 0·02 to 0·2% without detriment to the final product.

The castings were, of course, completely white as made, and, by the use of such low silicon content, there was little chance of there being any graphite separated, even in comparatively thick sections of metal. After the castings had been properly fettled, they were given a long period heat-treatment, being packed carefully in boxes along with particles of hæmatite iron ore. In this way, by suitable temperature control, and a final slow cooling, the resulting structure in the castings was that of a largely pearlitic matrix which imparted a considerable degree of strength to the malleable iron, and the small particles of amorphous carbon left produced the minimum amount of reduction in the strength. As there was also a considerable amount of free ferrite in the internal structure, as well as at the skin of the finished casting, there was a fair amount of ductility in the metal, and any distortion which the castings had suffered from the heat-treatment could be easily removed by cold straightening.

Several interesting points were explained, and the excellent wearing property of white-heart malleable iron was described under various conditions of severe service. A comparatively new application was also described whereby a very high surface hardness could be imparted to the finished machined article by making use of the "Shorter" flame for skin-hardening the article kept under water.

Protective Metallic Coatings.

WHAT has come to be regarded as an outstanding annual feature in the meetings of the Manchester Metallurgical Society was held last month in the Engineering Department of the University, when a symposium and demonstration took place on the interesting subject of "Protective Metallic Coatings." The Honorary Secretary, Mr. E. O. Jones, introduced the matter in a short paper, in which he reviewed the chief methods adopted for coating metals for the purpose of minimising the effects of atmospheric and high temperature corrosive action. Dealing first with ferrous metals, the high annual loss of these, due to corrosion was pointed out, and the two sources of loss explained as classified under the headings of direct chemical attack and electro-chemical action. The corrosion produced may be either general or localised, the first being slow and not generally dangerous, but the latter is usually more rapid and likely to cause speedy failure. Suitable precautions to minimise corrosion were given as (*a*) the use of special corrosion resistant alloys; (*b*) preliminary treatment of water which was causing trouble; and (*c*) preliminary treatment of the metal to provide it with a protective coating. These protective coatings might be applied either in the form of (1) another metal, (2) other materials, such as paints, enamels, oxide films or grease.

The metallic coatings could be applied either by (*a*) hot dipping as in tinning and galvanising; (*b*) electro-plating—*e.g.*, with copper, nickel, or chromium, etc.; (*c*) heating with metallic dust; (*d*) spraying with molten metal; or (*e*) mechanical welding. Such coatings have certain defects, since any save gold and platinum are corrodible; and there is often discontinuities in the coating which give rise to a corrosion couple, thus causing anodic attack of the more reactive metal. Provided the overlying metal is the more reactive, then the under metal is protected by what is known as sacrificial corrosion of the applied coating. Successive speakers dealt with the special applications of quite a variety of processes which were in nearly every case complementary to one another; so that there was very little overlapping of their sphere of usefulness.

Machining of Steel is Conditioned by Quality of Steel.

Under the above title, H. H. Bleakney discussed the machining of steel in an article published in *The Iron Age*, December 24, 1931, in which some interesting views were expressed. It is, however, only possible to deal with the article in abstract.

Non-metallic inclusions are a source of trouble in machining operations for which the steel maker must accept the responsibility—within reason. But in many cases the effect of the structural condition of the steel upon the machinability far outweighs the influence of the inclusions. A sorbitic or spheroidised structure rather than a pearlitic one is much more deleterious than the presence of inclusions.

The best machinability is encountered when both the hardness and the ductility of the steel being cut are at a minimum; where surface is not a major consideration, low hardness is more important than ductility. An annealed product, with a uniform lamellar pearlite, means smooth, rapid operation on the machine lines, with excellent tool life.

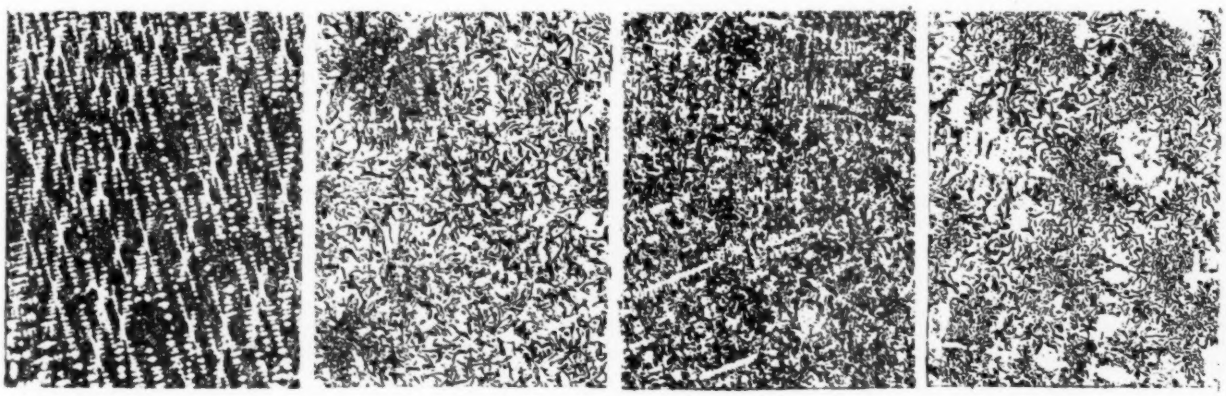
No mention is made of the deleterious result of the heat-treatment upon the life and resistance of the machined gears to shock, as the introduction of lamellar pearlite instead of sorbite, especially, very materially lowers the shock and abrasion resistance value of such embrittled steel.

Recent Developments in Cast Iron

By J. G. Pearce, M.Sc., M.I.E.E.

The development of austenitic irons and progress in heat-treatment are the outstanding features of cast iron during the recent year.

PERHAPS the most outstanding feature of cast iron from the metallurgical point of view during 1931 has been the development of austenitic irons and of progress in the heat-treatment of grey iron. The general advance of cast irons since the war has been mainly through the spread of metallurgical knowledge with respect to the influence of elements of composition on the structure, and to the wider application of metallurgical control, which enables the founder to work on closer margins with respect to composition, and hence to produce more closely to specification and to higher specification figures. The result has been that cast iron, which at one time was a heterogeneous mixture of pearlite and ferrite with flake graphite, is now in the ordinary way completely pearlitic throughout. This has recently been observed even in the case of such thick-walled castings as ingot moulds for steel ingot. This change has brought about a homogeneity and uniformity of structure, throughout given sections, which makes for uniformity of properties, physical and mechanical, in the casting. At about 700° C. these pearlitic irons undergo the well-known constitutional change, pearlite changing to austenite. Some elements of composition, notably silicon, raise this point, whereas others lower it, particularly nickel, chromium, copper, and manganese. If these elements are added in sufficient quantity and in suitable proportions the pearlite change point can be depressed to below air temperature, so that the metal is austenitic in the cold state. Austenitic irons have very useful properties for various purposes, and several papers, particularly those by Hurst[1] and Twigger,[2] have been devoted to them during the year. Their thermal expansion is greater than that of ordinary pearlitic iron, being about 18 to 20×10^{-6} against 13 to 14×10^{-6}. They are soft and easily machined, and do not undergo any change on heating. They frequently have a slight measure of elongation in the cold. A well-known example of this class is the material known as "Nimol," an iron of somewhat similar character to ordinary good grey iron, but with 12% to 15% nickel, 5%—7% copper, and 1·5%—4% chromium, the properties of which have been recently given by Bell.[3] Fig. 2 A and B show a sample of Nimol etched at 50 and 200 diameters respectively, this being from centrifugally cast material. Because there is no change on heating, the austenitic irons are usually resistant to heat, and they are also either weakly magnetic or non-magnetic and resistant to corrosion. Another austenitic iron has recently been produced by the British Cast Iron Research Association, known as Nicrosilal, and it may be regarded as a development of the Silal heat-resisting, scale- and growth-resisting cast irons high in silicon. The Silal irons contain 5% or 6% of silicon as a rule, although this may be increased for some purposes up to the limit of machinability, about 10%. Containing 5% to 6% silicon, they can be used up to 900° C. They consist of fine graphite in a matrix of ferrite, there being no pearlite to break down at the usual critical point, about 700° C., and the fine graphite precludes the entry of oxidising gases. Fig. 1 is a composite photomicrograph of Silal cast iron etched at 50 diameters, all from cupola-melted, commercially made material. A is a 0·125 in. section, B the same metal from a 0·25 in. section; C and D represent similar material from another casting in the 0·25 in. and 1 in. sections respectively. Nicrosilal also contains nickel and chromium as added elements, and the silicon content confers remarkable resistance to scaling. C and D, Fig. 2, show a sample of Nicrosilal etched at 50 and 200 diameters respectively. The smaller magnification shows the graphite distribution and the larger the matrix, which shows austenite and small areas of chromium carbide. It has been found that Nicrosilal will not scale even up to its melting point at about 1,150° C., and a sample heated to 1,000° C. in a gas muffle for periods aggregating 3½ hours showed a growth of only 1·3% in volume, which is about one-quarter of the thermal expansion at this temperature. It is, of course, easily machinable. A similar test on an ordinary engineering iron containing 1·7% silicon showed a growth of 16% and heavy scaling, while a straight Silal iron, which is normally not recommended for temperatures over 900° C., showed a growth of 5% and superficial oxidation only. At 800° C. Nicrosilal has a tensile strength of between 2 and 3 tons per sq. in., and at the same temperatures other tests have shown that Nicrosilal is much more rigid under load than ordinary engineering irons, which begin to fall off rapidly in strength at 400° C. to 500° C. In the cold a sample was found to have an elongation on 2 in. of 3%.



A × 50 *B* × 50 *C* × 50 *D* × 50

Fig. 1.—Silal Heat-resisting Iron.

The heat-treatment of cast iron is being used commercially after a good deal of experimental work, and there

1 *Foundry Trade Journal*, October 15, 1931.
2 *Foundry Trade Journal*, December 17, 1931.
3 METALLURGIA, December, 1931.

is little doubt that it is of material value in obtaining a more regular and uniform structure and a finer grain size. It has been found by Hurst[4] that ordinary cast iron can be hardened by oil-quenching, but less in thicker than in thinner sections, and that the hardening capacity is increased by the presence of nickel and chromium. Twigger, in the above-mentioned paper, also deals with heat-treatment.

An interesting investigation by West[5] has demonstrated qualitatively, if not quantitatively, the greater risk of shrinkage involved in using low-carbon irons. The high tensile strength of these irons or their wearing properties makes them very attractive to the engineer, but care has to be exercised in the design of the casting and in the moulding and pouring if the consequences of the higher shrinkage are not to involve too much risk to the soundness of the casting.

Work on alloy cast irons has been considerable, and a summary of this and some practical applications of these materials has been given by Bell.[3] A useful summary has also been published by the Bureau of Information on Nickel.

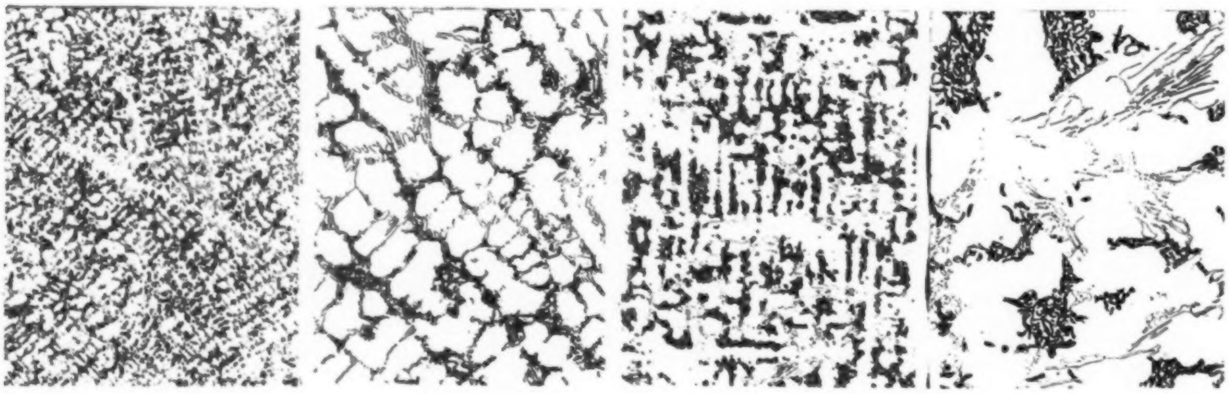
With respect to melting furnaces, several installations of two types of rotary pulverised-fuel melting furnaces have been put into operation, and further developments are expected (METALLURGIA, April, 1931, and *Foundry Trade Journal*, December 17, 1931). There is no doubt that this furnace will offer great possibilities in the production of high-quality cast iron and malleable iron. Robiette[6] has drawn attention to the possibilities of the coreless induction furnace for superheating cast iron. Superheating is of great interest and importance to the metallurgist, but requires to be carefully watched. Indiscriminate superheating has been found to result in practical difficulties which can be overcome by making use of recent investigations on the properties of cast iron. A notable contribution has been made by Fletcher to the development of the cupola furnace by the application of the valve control to the lower main tuyères, combined with provision for passing some of the air through smaller tuyères higher up the wind belt. A dozen cupolas of this design are in use or under construction for members of the British Cast Iron Research Association, and in all but special cases a melting ratio of 14 : 1 of metal to coke charged is obtained, the usual saving on ordinary cupola practice being of the order of 25% to 40%. A summary of this and other recent investigations carried out by the British Cast Iron Research Association has been published by the author[7] during the year, and reference may be made to another paper by Skerl,[8] summarising the work done by the same Association on moulding sands. On malleable iron an investigation has been undertaken by Norbury[9] on the influence of the size and shape of the test-bar, a point of great importance to the maker. It was found that the round bar is, on the whole, preferable to the flat bar (1 in. × $\frac{5}{8}$ in. × 8 in.), commonly used for so many years in the trade for the bend test, and that the thickness of the test-piece should be proportional to the thickness of the casting. This conclusion need cause no surprise. It is accepted for grey iron since 1928, and the use of a single bar for all thicknesses of malleable iron, where the material is purchased to specification, is prejudical to the maker and the material, and misleading to the designer.

Some valuable results have been obtained on the desulphurisation of cast iron by soda-ash, by Evans.[10]

The test-bar problem for cast iron was fully discussed at the Zürich Congress of the New International Association for Testing Materials, preceded by four papers by well-known specialists, and the discussion, together with an official summary of the views expressed, will shortly be published by that body. There was an overwhelming preponderance of view in favour of the use of a separate test-bar for transverse and tensile tests as the best method of acceptance testing for castings, the case for the French proposals for trepanning the casting and testing the small piece removed thereby in single shear being poorly supported. The latter method, however, forms a useful means of exploring the strength of a casting in different sections, and as a research tool is very valuable. The author has shown that there is a greater difference between the strength of a simple casting and a trepanned piece than between a simple casting and a bar which represents it in accordance with B.E.S.A. specification 321-1928. Incidentally, a paper at the Zürich Congress by Schwarz illustrated the application of polarised light to the study of microstructure of non-ferrous alloys, and the beautiful effects obtained made a decided impression, as may be judged by the reproductions in colour given in the issue of METALLURGIA for October, 1931.

Results are accumulating on the fatigue properties of cast iron and work on "creep" is beginning. Results to date show that cast material behaves surprisingly well compared with forged and wrought material, and enterprising founders will probably wish to see ordinary static tests supplanted in favour of the more modern tests, which, after all, often reflect more faithfully the conditions under which material is expected to work in service. It has been shown that under-stressing cast iron to its endurance limit is capable of raising that limit nearly one-third, and that endurance limit is already relatively high compared with the steels.

On the plant and equipment side, apart from the developments mentioned above, the year has been notable for the opening of the new plant by the Staveley Coal and Iron Co., Ltd., for the manufacture by centrifugal methods of



A × 50 *B* × 200 *C* × 50 *D* × 200

Fig. 2—A and B Nimol; C. and D Nicrosilal.

4 *Foundry Trade Journal*, December 3, 1931.
5 METALLURGIA, October, 1931.
6 METALLURGIA, October, 1931.
7 METALLURGIA, June, 1931.
8 *Foundry Trade Journal*, July 23, and August 6, 1931.
9 *Foundry Trade Journal*, September 17 and October 1, 1931.
10 METALLURGIA, December, 1931.

(*Continued on page* 92.)

Vanadium, its Ores, Methods of Extraction, and Applications

The increasing use of Vanadium as an alloying element is due to its influence in reducing the grain growth of steel and in refining the structure. It improves the forging qualities of steels and gives greater uniformity in response to heat-treatment

DISCOVERED by Del Rio in 1801, Vanadium is a greyish white metal somewhat resembling antimony in appearance. It is very hard, and is not affected by air or water at normal temperatures, but at elevated temperatures it readily combines with oxygen and nitrogen as well as numerous other elements. It is a powerful reducing agent, and is used to remove oxides and nitrides from molten metal, more particularly steel. Apart from its value as a reducing agent, it exerts a more powerful influence on steel than any metal yet discovered. Its general effect is to increase the tensile strength and elastic limit and to reduce elongation somewhat. Very small percentages impart to the steel remarkable toughness, which substantially raises the resistance of the steel to alternating stresses. Thus vanadium may serve both as a deoxidising and as an alloying element, but it is added to steel solely as an alloying constituent after deoxidation has been effected by cheaper materials.

Vanadium occurs only in combination in a number of minerals, the most important of which are Patronite (VS_4), Carnotite (K_2O, 2 UO_3, V_2O_5, $3H_2O$), Vanadinite ($3Pb_3$ $(VO_4)_2$, $PbCl_2$) and Roscoelite (H_8K_2, (M_gFe), $(AlV)_4$ $(SiO_3)_2$), although Mottramite also provides a source of supply. All the minerals in which it occurs are relatively rare, vanadinite being the commonest. The most productive of these minerals are the patronite deposits of Peru. Composed primarily of vanadium sulphides, the patronite deposits of the Minasregra mine of Peru yielded the bulk of the world's supply of vanadium until recently. No similar deposits are known in any other part of the world. Now, apart from mineral mined in Arizona, Nevada, New Mexico, Spain, Argentine, and Mexico, in Rhodesia and South-West Africa lead vanadate mines have been developed from which large and increasing supplies are available.

Ferro-Vanadium.

Most of the vanadium is used in the form of ferro-vanadium, containing from 30 to 85% vanadium in accord with the different requirements, and this is produced either by the Thermit process or in electric furnaces. The latter method, in which formerly successive charges were made in crucibles has now been adapted for use on a larger scale in which not only are the furnaces larger, but the operation has been made continuous with intermittent tapping of ferro-vanadium and slag. In electric furnaces the ferro-vanadium is produced by smelting iron vanadate, and the larger units and higher temperatures give more fluidity and better separation of slag and metal.

The practice of the Vanadium Corporation of America, based on many years' experience, is to employ a specially designed electric furnace with a restricted area between the carbon electrodes. Finely crushed coke, roasted ore and fluxes, are thoroughly mixed and fed by a special feeding device, so that the charge is introduced directly into the restricted area between the electrodes where the temperature is highest. Sufficient iron is included in the charge to produce ferro-vanadium of the desired grade. Fused ferro-vanadium and slag accumulate below the arc, and are tapped from the furnace.

Vanadium combines so readily with other elements that it is not easily isolated, and its production in a pure metallic state on a commercial scale has not yet been accomplished. The reduction of pure oxide by aluminium has produced vanadium of 93% purity, reduction of vanadium chloride by hydrogen has given a 95% product, and it is claimed that by carbon reduction a purity of 98% has been obtained.

Vanadium as an Alloying Element.

Used as an alloying element, vanadium has considerable influence on the properties of steel. A small amount may be dissolved in the ferrite, but the greater percentage probably forms complex carbides with the cementite, which seem to be uniformly distributed, preventing segregation and thus removing a cause of brittleness due to vibration. The action of vanadium exerts an influence which tends to reduce grain growth and to refine the structure. These are the outstanding characteristics of the vanadium and vanadium-alloy steels, in which the fine grain and general absence of lamellar pearlite increases the ratio of elastic limit to tensile strength with the maintenance of high ductility. The use of vanadium in forging steels required for high duty service not only affords advantages in strength, but, in some alloys, excellent properties are obtained without quenching. These steels are superior to many others, which yield essentially the same physical properties, because of better forging qualities, greater uniformity in response to heat-treatment, and better machining qualities. Relatively small percentages of vanadium, varying from 0·10 to 0·20%, bring about these improved physical qualities, giving results that are altogether out of proportion to the small amount of vanadium present in the steel. There is a marked affinity of vanadium for carbon, and the amount of the latter should be carefully controlled. A wide variety of vanadium steels are profitably used, from the straight carbon-vanadium steel to the more complex high-speed steel group of alloys.

Structural Steels.

Straight vanadium steels have a limited use for structural and engineering castings, more especially for heavy castings of irregular shape that cannot be quenched without risk. Suitable annealing increases the tensile strength about 30% over a corresponding carbon steel without vanadium. A typical carbon-vanadium steel contained 0·35% carbon, 0·40 % silicon, 0·90% manganese, and 0·18% vanadium conforms to the following specifications :—

Yield Point, Tons/Sq. In.	Tensile Strength, Tons/Sq. In.	Elongation % in 2 in.	Reduction of Area %.
22·5	38	22	45

Double normalising and tempering treatment improve the physical properties, and the results of tests on the casting after heat-treatment show :—

Yield Point, Tons/Sq. In.	Tensile Strength, Tons/Sq. In.	Elongation, % in 2 in.	Reduction of Area, %.	Izod, Ft.-Lb.
25	41	25	47	31

Each alloy used in steel making imparts certain specific qualities to the steel, and improves certain properties, but, as a rule, other properties are minimised, and in order to secure improvement in all properties many combinations of alloying elements have been developed commercially. In many of these combinations vanadium is finding increasing use, partly because it tends to intensify the effect of other alloying elements. Thus, for instance, in a chromium steel, vanadium brings out properties, as well as creating distinct conditions in heat-treatment, that are

not evident when either alloying element is used separately. For chromium-vanadium steels the improved combination of physical qualities is obtained with chromium ranging between 0·8 and 1·1%, and vanadium up to about 0·15%. A typical steel of this type consists of 0·30% carbon, 0·8% manganese, 0·4% silicon, 1·0% chromium, and 0·1% vanadium. To show the improvement resulting from the use of vanadium, the following data gives physical properties of the above steel with and without vanadium:

	Yield Point, Tons/Sq. In.	Tensile Strength Tons/Sq. In.	Elongation, % in 2 in.	Reduction of Area, %	Izod, Ft.-Lb.
Cr.	26·5	42·0	27·5	54·7	38·3
Cr. V.	28	42·0	27·5	57·1	59·3

The vanadium produces a finer structure and denser pearlite than is usually obtained from corresponding carbon or chromium steels, which improves the toughness and ductility.

Vanadium in nickel steels for castings is being used increasingly for railway service, steel-making plant, and many other forms of industrial equipment, where resistance to wear and tear, and to shock and breakdown through vibration must be greater than normal. Two varieties of nickel-vanadium steel are in use in which the difference in carbon contents influence the physical properties. Typical analyses are as follows :—

	C.	Si.	Mn.	Ni.	V.
Low carbon	0·22	0·35	0·85	1·50	0·10
High carbon	0·28	0·35	1·00	1·50	0·10

The physical properties of these steels are worthy of note ; results of tests show :—

	Yield Point, Tons/Sq. In.	Tensile Strength, Tons/Sq. In.	Elongation, % in 2 in.	Reduction of Area, %.	Izod, Ft.-Lb.
Low carbon	27·2	37·1	29·0	59·1	60
High carbon	31·0	42·0	28·0	53·8	47

There are distinct possibilities for steel castings from manganese-vanadium steels, and developments with manganese steels by the addition of vanadium have given a commercial steel of superior elastic and impact strength. The influence of vanadium is shown by comparison with results from experimental melts of a manganese steel containing 0·35% carbon, 1·40% manganese, 0·40% silicon, with and without the addition of 0·10% vanadium. The tests results gave the following physical properties :—

	Yield Point Tons/Sq. In.	Tensile Strength, Tons/Sq. In.	Elongation, % in 2 in.	Reduction of Area, %.	Izod, Ft.-Lb.
Manganese	26	45	27·5	58·8	25
Manganese vanadium	33	44	30·5	61·8	57

Produced on a commercial scale, this manganese-vanadium steel gave physical properties corresponding to the following :—

Yield Point, Tons/Sq. In.	Tensile Strength, Tons/Sq. In.	Elongation, % in 2 in.	Reduction of Area, %.	Izod, Ft.-Lb.
31	45·2	25	51·9	43

The improved granular structure obtained by the addition of vanadium to this type of steel improves the physical properties, and the notable increase in yield-point and in impact value merits the careful consideration of all who are faced with problems associated with the construction and maintenance of cast parts subjected to severe shock loads.

Manganese-vanadium steels of lower carbon content also exhibit these advantageous physical properties, as will be noted in the following data :—

Composition. C.	Mn.	V.	Yield Point, Tons/Sq. In.	Tensile Strength, Tons/Sq. In.	Elongation, % in in 2 in.	Reduction or Area, %.	Izod, Ft.-Lb.
0·22	1·64	0·09	27·8	37·5	34·0	68·7	89·5
0·23	1·69	0·09	29·0	40·0	32·0	66·0	87·5
0·29	1·33	0·11	28·0	40·0	31·0	63·5	73·5
0·29	1·38	0·10	31·0	41·5	30·8	61·1	61·0

The importance of the impact strength of cast steels for special service, where high impact value affords a great measure of insurance, is gradually being appreciated, and vanadium is finding increasing usefulness in imparting this quality to the harder and more complex alloy steels.

The combination of high yield point, high tensile strength, and proportionately high impact resistance of some complex alloy steels of the following compositions is given in the appended table.

Type.	Composition. C.	Mn.	Si.	Mo.	Cr.	Cu.	V
Mn. Cr. V.	0·44	1·48	0·47	—	0·61	—	0·10
Mn. Cu. V.	0·43	1·48	0·44	—	—	0·80	0·10
Mn. Mo. V. (I.)	0·45	1·53	0·48	0·16	—	—	0·10
Mn. Mo. V. (II.)	0·36	1·17	0·48	0·33	—	—	0·10

Physical Properties.

Yield Point, Tons/Sq. In.	Tensile Strength, Tons/Sq. In.	Elongation, % in 2 in.	Reduction of Area, %.	Izod, Ft.-Lb.
33	53·5	25·0	56·2	34
38	54·0	22·0	46·3	44
37·5	57·0	20·5	35·0	30
41·0	60·0	12·0	25·4	25

All the steels referred to have been tested after a double normalising treatment either with or without a subsequent tempering, but when the form of the castings will permit, more drastic heat-treatment—liquid quenching followed by tempering—may be applied to produce still greater improvement in stress-sustaining capacity.

Forging Steels.

Steel containing vanadium may be used instead of nickel and nickel-chromium steels of similar carbon content for special forgings which require greater strength, toughness and resistance to fatigue than is possible with plain carbon steel. In addition to increased physical properties, the greater ease of working gives the vanadium forging steels advantages, those of the chromium-vanadium type being especially useful. Steel of varying carbon contents may be used according to the physical and working properties desired. Compositions especially suitable for heat-treated forgings required in the motor-car industry conform to the following: Carbon, 0·35–0·45% ; manganese, 0·50–0·80% ; chromium, 1·00–1·50% ; vanadium, 0·20%. Steel of this type possesses a high ratio of yield point to maximum stress, together with cleanliness and general soundness. Heat-treatment advised is: heat to 850° C., quench in oil, followed by re-heating to 500° C.–650° C., and allowing to cool in air.

The following are the mechanical properties which can be obtained from steel of this type after the above treatment :—

Tensile Strength. Tons/Sq. In.	Yield Point. Tons/Sq. In.	Elongation, % in 2 in.	Reduction of Area, %.	Izod Impact Ft.-Lb.
55–65	45	18	50	40

It is used for such highly stressed parts as connecting rods, driving shafts, axles, propeller shafts, etc.

Machining is generally done before heat-treatment, a small allowance only being left for final grinding after treatment. This type, with modifications in analysis to suit particular requirements, is also used for such parts of heavy machinery as are subjected to alternating stresses and shocks—for example, rolling mills, piston rods for hammers, shafts, and spindles for crushing machinery.

Another grade of chromium-vanadium steel which is used in the motor-car industry for leaf springs contains a slightly higher percentage of carbon, generally from 0·45 to 0·55%.

This grade of steel has proved to be ideal for all classes of leaf springs due to its high elastic limit and fatigue resistance. In addition, uniformity of results is obtained on mass-production methods. It is used in the oil-hardened and tempered condition. The following properties are obtained after hardening and tempering. :—

Tensile Strength. Tons/Sq. In.	Yield Point, Tons/Sq. In.	Elongation, % in 2 in.	Reduction of Area, %.	Brinell Hardness.
85·95	80·90	15–10	45–30	375–450

Of other types of vanadium forging steels, mention should be made of the straight carbon steel, to which vanadium is added in percentages from 0·10–0·20, a typical analysis being as follows: Carbon, 0.45–0·55% ; manganese, 0·40–0·60% ; vanadium, 0·15–0·20%. This grade of vanadium steel is used in locomotive construction for such parts as piston rods, main and side rods, crank-pins, axles, valve-motion gear, and other forgings which are usually made of carbon steel hardened and tempered. It is used in the normalised and annealed condition, so eliminating defects found in hardened and tempered steels. The following tests give some indication of what can be obtained from this steel in the normalised and annealed condition :—

Tensile Strength, Tons/Sq. In.	Yield Point, Tons/Sq. In.	Elongation, % in 2 in.	Reduction of Area, %.
43·0	28	22	45

Tool Steels.

Vanadium is one of the usual constituents of high-speed steel which has the property of red-hardness. Its use constituted the most noteworthy departure from the self-hardening and early high-speed steel analyses. To-day it is generally accepted that the addition of vanadium in suitable proportions improves the quality of tungsten-chromium high-speed steels. Although beneficial results are acknowledged in view of the improved efficiency in machine-shop practice, opinions differ regarding the metallurgical effects of vanadium. Some consider that primarily its effect is to clean the steel and thus assist in producing a higher grade alloy possessing increased hardness, greater strength and resistance to shock. In this its value is considered to be due to its effect on the metal rather than to its direct influence as an alloying element. Other high-speed steel makers consider that, in addition to its indirect effect, it increases red-hardness, due either to its own direct effect as an alloying element or in combination with other alloying constituents. Yet other makers find that within limits it may be used to displace tungsten in the ratio of 1 of vanadium to 3 or 4 of tungsten.

There are many brands of high-speed steel with slight differences in analyses, but the two principal types in commercial use are the 18% and 14% tungsten steels, the former containing from 0·5 to 1·0% vanadium, while the lower tungsten content steels may contain up to 2·0% vanadium.

Conclusion.

The beneficial effects of vanadium on steel are obtained by the use of very small percentages, and it is only natural that to obtain satisfactory and uniform results the steel must be made carefully. This is perhaps specially necessary in the case of vanadium, since this metal affects the action of other alloy metals present, and if they are in the wrong proportions the benefit of vanadium is reduced.

Finally, it must be borne in mind that neither vanadium nor any other alloy metal will make bad steel good. Alloy steel-making is an exact science—not only the percentages of the alloy metals, but those of the impurities influence results drastically—good quality raw materials are therefore essential for the best results, and careful adjustment of the different ingredients is necessary for uniformity.

THE MUD GUN AND ITS OPERATION.

THE effective stopping of the blast-furnace tap-hole demands some skill in the operation of the mud gun as well as care in the selection and preparation of suitable material. It is, of course, important that the stopping material should have the correct properties. It must be refractory, yet not too hard, and in its dry state still capable of being worked with the tapping bar. A certain measure of porosity is necessary to enable the moisture to evaporate, otherwise explosions may occur on tapping. Further, the material must not crack in drying, but should possess a certain amount of tenacity.

In the preparation of the stopping material, small coke, coal washings, and clay may be used. The following proportions have been found very satisfactory for normal tap-holes :—

5 parts ground coal-washings.
1 part green clay with about 10% alumina content.

For tap-holes in very bad condition, the following approximate proportions are recommended :—

2 parts ground coal-washings.
1 part clay as above.

Sometimes a little tar is added, but this is not essential. The use of coal-washings or slurry is advantageous, because they contain fine particles of coal, which become coked when the stopper is heated, thereby rendering it porous. The shale usually present in coal-washings imparts a certain degree of toughness to the stopping material. All the raw materials should be well ground in a pug mill, after which it is advisable to mix and wet them thoroughly in a mixer.

In charging a machine, such as the Simplex mud gun, it is necessary to shovel the stopping material into the hopper, pushing it along repeatedly with the plunger until the entire clay space is filled. The foremost layer of material in the nozzle should be dried to a depth of about an inch. This is most easily effected by means of hot slag or a coke brazier. If the material at the front end of the nozzle is very moist, there is danger of an explosion on contact with the molten iron, owing to the formation of oxyhydrogen gas.

It is better not to charge the machine until shortly before tapping, so that the material does not have time to dry up.

Normal Stopping.

Under normal conditions the mud gun is designed to hold ample material for one stopping, and if the tap-hole is in good condition, it is unnecessary to repeat the stopping. When the charge is being applied care should be taken that the plunger is not jerked forward intermittently, but that the stopper is slowly forced into the tap-hole by a continuous and gradual advance of the plunger, otherwise the stopper may be pushed through into the molten iron and float to the top without closing the hole. When stopping is finished, the machine should be left in front of the tap-hole for a time, until the material has begun to set.

Repeated Stoppings when Tap-hole is in Bad Condition.

It is generally known that, normally, the tap-hole should have a length equal to the thickness of the hearth lining. It often happens, however, that the brickwork behind the hole is largely eaten away. In such cases not only must the tap-hole be stopped, but the cavities resulting from the eating away of the brickwork must be made good by filling up with stopping material. For this purpose a number of stoppings are required. After stopping the tap-hole, therefore, the slide already mentioned closes, when the plunger is withdrawn and the clay space in front can be filled. In such cases also the material should not be suddenly pushed through the tap-hole, but forced in very slowly, so that it has a chance to spread mushroom-like inside the furnace to the places to be mended on both sides of the tap-hole.

It not infrequently happens that, because length of the tap-hole is equal to the thickness of the hearth, the tap-hole appears to be in order, whereas, in reality, there are large cavities to its right and left. This is due to the fact that the tap-hole is cooled by the moist stopping material, so that the brickwork adjoining it is protected, while at a distance, where this cooling is no longer effective, such cavities are produced.

It is advisable now and then to drill the hearth to the right and left of the tap-hole, with the object of ascertaining whether the thickness of the brickwork is still adequate. The stopping material can then be injected through these holes to mend any cavities that may be present.

Sand Deposits Purchased.

General Refractories, Ltd., Sheffield, who have works in England and Scotland, have purchased the Levenseat sand and fireclay works and quarries at West Calder belonging to Messrs. J. and T. Thornton, Hermand, West Calder. There are deposits of sand of high quality suitable for glass-making, furnaces, and other purposes, and the works have good transport facilities.

Correction.

The agreement entered into by Messrs. Birmingham Electric Furnaces, Ltd., referred to in "Business Notes and News" page of the December issue, is with C. I. Hayes, Inc., and not C. I. Kayes, Inc., as published in that issue.

Metal-cutting and Hard Cutting Materials

Some recent investigations with the object of discovering the most effective use of machine tools and cutting materials are discussed.

IT is doubtful whether there has ever been made such diligent searches for economies of operation as those being conducted to make the most effective use of modern machine tools. It has concentrated attention on various hard cutting materials that, in regard to speed of cutting and service, are being used successfully in overcoming the difficulties presented by the increasing demand for ferrous and non-ferrous products capable of withstanding high-duty service. In this work the American Society of Mechanical Engineers take a very active part, and at their recent annual meeting an informative paper on the "Elements of Milling" was presented by O. W. Boston and C. E. Kraus, while the progress report No. 3 of the Sub-Committee on Metal-cutting Materials was presented by Coleman Sellers; it is, however, only possible to refer to these somewhat briefly.

Elements of Milling.

This paper presents the results of a series of tests in milling a variety of ferrous and non-ferrous metals. The energy required to remove a chip of a given metal when milling "up," when the work is fed into the cutter, and that when milling "down," when the work is fed with the cutter, were determined and compared. Cutting was done wet and dry. A number of different types of cutting fluids were used, and these are tabulated. Data showing the influence of variable feed with constant depth and variable depth for constant feed are shown. Formulas representing the energy required to mill a given chip as a function of the feed and depth are developed for a number of materials, when cutting both wet and dry and when cutting up and cutting down. Tests were run with the cutting edge of the tool in various conditions of sharpness, such as very sharp, dull, and very dull, to find the influence of this variable on the energy required to remove a given chip.

The cutting was done with the cutter rotating in a plane perpendicular to the surface of the work, and in all cases data for two fundamental methods of cutting are shown: first, milling up in the regular way with the work being fed into the cutter, and second, milling down with the work fed with the cutter. In nearly all cases a difference in energy is found between these two methods of cutting.

Data giving the energy in foot-pounds necessary to remove a single chip are shown for thirteen widely different materials with constant feed and various values of depth, and then with constant depth and various values of feed. Several different cutting fluids were used. These data are plotted and energy equations are derived for each material, of the form $E = Cwf^{x}d^{y}$, where E is the energy in foot-pounds per chip, C a constant for the specific condition, w the width of the cutter in inches, f the feed in inches, and d the depth of cut in inches. Values of the constants are given. Corresponding formulas and values for the horsepower per cubic inch per minute are also given. No two materials give the same values of the exponents for the feed and depth variables.

Data are also shown for milling with the cutter in the sharp, dull, and very dull conditions, to determine the effect of the sharpness of the tool on the milling-energy formulas. It is found that dulling does change the formula, but has greater effect on feed than on depth of cut.

Tests were run on four materials using eleven different cutting fluids to determine the effect of cutting fluids on milling energy. It is concluded from the nature of the tests that lubrication rather than cooling has greater effect. The data show a different order for the fluids for each material, but in nearly all cases a power saving is made by their use.

Milling-energy data are also presented for a large variety of materials when the cut was held constant at 0·125 in. depth, 0·010 in. feed, and the cutter was 0·250 in. wide and had a 15° front rake angle, in order to compare these materials from a milling-energy standpoint. It is concluded that there is no way, other than actual test, to determine the milling properties ot a material.

A discussion of previous milling papers has been added, and an analysis of the form of a milling chip is presented. It is concluded from this analysis that, theoretically, the coarse-tooth cutter is better than the fine-tooth cutter, when milling up, keeping the linear feed per tooth constant. When milling down, however, the fine-tooth cutter removes a chip of greater average thickness than the coarse-tooth cutter, and consequently is considered to be more efficient from a power standpoint when diameter and feed per tooth are constant.

The fine-tooth cutter cutting down produces the greatest average thickness of chip of all combinations, and is thought to be the most efficient way of milling metal when power is the chief consideration. It is shown that the average thickness of chip when both feed and depth of cut are varied is not a satisfactory basis for an energy equation.

Tungsten-carbide and other Hard Cutting Materials.

Since the publication of the last report of the Sub-Committee on Metal-cutting Materials, in June, 1930, the activities have been widened to include not only tungsten-carbide, but other hard cutting materials. This report deals with a questionnaire sent out to leading manufacturers asking all who had experience with tungsten and tantalum carbide or other new alloys to answer the questions as far as possible. It is of interest to note that the answers indicate considerable progress, not only in the number of users of these materials, but in that many that were using little have found it worth while to extend the use.

Over 100 replies were received, 85 of which gave information on which this report is based, an increase of 70% on the suitable replies to the questionnaire which formed the basis of a previous report. The first part of the questionnaire deals with general questions, the replies to which are covered in this report, together with comments on some of the users. The second part asked for information on typical applications, some of which are given in tabular form.

The replies indicate that 73 firms used tungsten-carbide tools. The percentages varied up to 48%, but only 20 firms used over 5%. Cobalt high-speed steel was not used by as many, but those that did used a higher percentage. Thus, of 45 users, 22 used more than 5%; the maximum percentage used was 85, while 8 used more than 50%. Only 7 firms reported the use of tantalum carbide; 2 used 3%, 1 less than 1%, and 4 were experimenting with this material. Stellite was used by 53, of which 32 used 5% or under. The maximum percentage used was 81, and this was the only firm reporting over 50%. The diamond as a cutting tool was not popular, but 9 reported its use—3 at 2%, 3 at 1%, and 3 at less than 1%.

The report indicates that much has been learned about tungsten carbide in the past year and a half, but reveals that there is a great deal more to learn and scientific data are needed most. Apparently, machine-tool manufacturers have not made much progress, probably because of the lack of definite information as to how far they should go and along what lines they should proceed. Experiments and tests on cutting materials are at present in progress, and interesting developments may be expected.

Aluminium Sheet Production

By Robert J. Anderson, D.Sc.

Part XI.—Planning Methods.

Methods of planning the mill practice in producing aluminium sheet of various sizes, gauges, and grades are discussed; typical mill tickets and tables for use in calculating are shown; and typical examples of order calculations are given.

SYSTEMATIC planning of the mill practice, particularly of the hot break-down programme, constitutes one of the most important steps in the economical and efficient rolling of aluminium-sheet products. Reasonably exact calculations must be made for each order put into operation in the mill so that the maximum recovery may be obtained per ingot, shearing losses may be held minima, and undue shortages or overages may not occur. Each lot of sheet to be processed should be planned, whether rolled to fill a customer's order or for stock.

The primary object of planning sheet production is to provide a systematic basis for operation from which the desired results can be forecast with reasonable accuracy, assuming average performance in the mill. As a rule, the more careful the planning the higher the recovery of acceptable sheet per ingot and the better the all-round operation in the mill. Of course, the most skilful planning cannot undertake to make allowance for all the losses which may arise in the processing owing to abnormal inequalities of operation, poor metal, incorrect practice, mistakes, and the human element. On the other hand, careless planning tends to encourage lax performance in the mill and to increase certain readily avoidable losses. Needless to say, perhaps, a good planning department not only issues instructions for the processing, but also ascertains whether those instructions have been followed and keeps close check on the losses which arise. Preferably, the planning department should be housed in an office situated in the mill proper so that easy access may be had to all sections of the building. The scheduling and tracing of orders should be done by the planning department.

Aluminium-sheet orders are normally run in lots—so many ingots to the lot. The size, or weight, of the lot is governed by several factors, including the size of the order, the type and size (including the gauge) of the material rolled, and the capacity of auxiliary mill equipment, such as buggies and scales. Lots may vary in weight from a few hundred pounds or less up to, say, 3,000 lb. or more. In a given mill, an order for 30,000 lb. of sheet or coil may, for convenience, be split into ten or twenty lots. Each lot is then processed as a separate order, being combined, when finished, with the companion lots to make up the total poundage of the order. Relatively small orders, say, between 200 and 2,000 lb. in weight, for example (depending on the size, gauge, and class of material) should be rolled as single lots. This avoids the possibility of small split parcels becoming temporarily lost or misplaced. Two or more orders for small parcels of the same kind of material may be combined so as to make a lot of reasonable size for processing, the combined lot being split, after inspection, for the separate orders. Preferably, the individual lots should be as large as may be conveniently handled with the available equipment, but no larger. That is to say, the weight of the lot should be so adjusted as to avoid re-handling and extra movement of metal in the mill. If the total weight of a lot exceeds the maximum capacity of the available scales—*e.g.*, at the slab shears—the lot will have to be split into two or more parcels for weighing. This is undesirable.

As has been pointed out in an earlier article of this series[1], knowing the size and gauge of material to be rolled, the number of sheets or coils to be obtained from each ingot—*i.e.*, the number of cuts or splits per slab,—and the scrap allowances for shearing, the size of ingot required can be calculated precisely. Also, while a certain size of ingot will yield the least scrap loss for each size of sheet, or will give the maximum recovery, it is impractical and unnecessary to use more than a few standard sizes. Good planning is concerned with getting the greatest possible recovery of acceptable sheet from each ingot with the least amount of work. The relation of ingot size and finished sheet size is discussed more fully and indicated by an example later in the present article. In many cases, several, or a considerable number, of finished sheets are obtained from an ingot, but if large sheets are rolled, only one or two sheets may be obtained per ingot. In the production of coil, one or several coils may be obtained per ingot. When more than one coil is obtained from an ingot, the slab may be split at the stock shears before roughing or finished as a single coil, and cut to width on a slitter.

Efficient planning of sheet production requires detailed knowledge of all the processing operations in the mill. In making up rolling schedules, which should be done by the planning department at the time when the orders are calculated, first-hand information should be available regarding the normal rates of production of the various sizes, gauges, and classes of material. Due allowance can then be made for fast- and slow-running stock. In calculating hot break-down orders, much time can be saved by the use of short-cut methods, involving convenient tables and charts.

Mill Order Tickets or Forms.

Orders for rolling should be delivered to the mill office in typewritten form, specifying in detail the size, gauge, grade, number of pieces or pounds, and delivery date wanted. For convenience in planning and scheduling, sundry order tickets or forms are used. Orders may be figured on pads of blank paper, subsequently to be filed, so that a record of the calculations is available. After calculating an order, mill tickets are made out for each lot put into operation. These tickets give instructions for the processing from the ingot to inspection. Spaces are provided in which the mill hands may write their time records covering various steps in the processing. Spaces are also provided for inserting the results of the inspection. Lots are numbered in consecutive order, and may be run 1 to 9,999, A1 to A9,999, etc.

Separate tickets are ordinarily made out to cover the hot break-down programme for the day as well as for the stock-shearing operations. In some mills, separate tickets are also made out to cover the slabbing on flat sheet and the first roughing on coil. These separate tickets cover the respective operations on a multiplicity of lots, and they are sent to their proper places in the mill before the shift starts to work. When the processing covered by the hot-mill or shear orders has been completed, the corresponding tickets are returned to the planning department. The mill tickets, applying to the individual lots, are held in the planning department until a lot of metal has been hot rolled, trimmed, and sheared, and is ready for roughing. Then, the data from the hot-mill and shear-order tickets are applied to the mill tickets. Starting with the roughing operation, the mill ticket "rides with the lot," being

[1] R. J. Anderson, "Aluminium Sheet Production. Part V.—Rolling Ingots," METALLURGIA, Vol. 2, No. 16, February, 1931, p. 137.

returned to the planning department after the inspection has been completed. All these various tickets are made out at least in duplicate, one copy being on file in the planning office while the other is in the mill.

Properly handled, the mill ticket gives a complete history of each lot of metal put into operation, covering all essential details from the ingot through inspection. For convenient reference, mill tickets applying to completed lots may be bound in book form and indexed as regards size, gauge, and grade of material. As above indicated, the processing times for the different operations may be written on the mill tickets. After being returned to the planning office, the time-record data may be worked over by the cost department, and the prime manufacturing cost of each lot determined.

The foregoing description gives an idea of how mill tickets and other order forms may be handled, but, of course, sundry variations may be applied.

Table I shows a form which may be used in issuing instructions to the hot-mill foreman for the break-down programme. This form may be printed on sheets of paper, measuring $8\frac{1}{2}$ by 11 in., ruled as indicated. About 25 spaces are provided by lines ruled horizontally, $\frac{5}{16}$ in. apart.

Table II shows a form suitable for issuing instructions as to stock shearing.

Table III shows a form of mill ticket which is made out to accompany each lot through the mill.

Detailed explanation of these forms need not be given here, their use being self-evident. In the case of the mill-order ticket (Table III), a space is provided at the left of the several lines reading "Furnace No.," etc., so that where annealing is required at any stage on the way down to the finished gauge, or after finish rolling, this may be so indicated by the use of a rubber stamp.

General Aspects of Planning, and the Effect of Mill Practice.

The effect of mill practice, in producing aluminium sheet and coil, on the methods and problems of planning will be more apparent after reading descriptions of the various processing operations—slabbing, roughing, finish rolling, annealing, shearing, etc.—in later articles of this series. Here, only the more general aspects of planning can be considered, but sufficient details, together with a number of examples, are given to elucidate the fact that planning methods and the details of mill practice are inextricably related.

The specific mill practice followed in rolling aluminium and aluminium-alloy sheet products is necessarily governed by various factors, including the composition of the material to be made, by its size and grade (including gauge and temper), and by the equipment available for the manufacturing. What may be good practice in a given mill for certain conditions may be poor practice in the same plant for another set of conditions. Also, the same results may be obtained in different mills by different methods of operation, local variations in practice being perforce developed in order to make the best use of the available equipment. At the same time, there necessarily must be, and are, certain generally accepted rules of practice which are currently followed in all plants. Systematic planning must be done on the basis of these rules.

A highly, if not the most, important consideration in planning is the question of ingot size. The selection of ingot size with respect to the size of the finished material to be made has direct bearing on the hot break-down operation, dimensions of the slab, cuts and rough shearing, and the recovery per ingot. This is particularly true in the case of flat-sheet production, more especially with the larger sizes. Generally speaking, the choice of ingot size assumes less importance in the case of coil production. The size of ingot may, and must, be varied over a considerable range, depending on the size and gauge of sheets to be rolled, but practical experience has shown that the great bulk of commercial requirements may be met with a certain standard size ingot—or, at most, with a few sizes. That is to say, the bulk of the production in a given mill can be run satisfactorily by using some standard average size ingot. As stated in a previous article,[2] this means that, when such size ingot is used for rolling the run-of-mill production, the average quantity of operating scrap (including normal and excess shearing losses and the amount of metal turning up at the heavy-duty shear as "shorts" or overages) will be minimum. Good planning calls for the employment of a relatively few sizes of ingots. Of course, if the standard size ingot would yield an excessive shearing loss, the proper size, either larger or smaller, should be chosen for rolling a given size of sheet.

Determination of the proper size, particularly thickness and width, of slabs to be rolled in the hot break-down operation is another important consideration of planning. Sundry factors influence this determination, including ingot size, gauge, and surface dimensions of the finished sheet or coil, temper, and shearing allowances as affected by gauge and composition. It is usual practice to hot roll aluminium slabs to the required widths and to nominal thicknesses in the range 0·2 to 0·5 in., the length being allowed to run.[3] When slabs are to be cut into a number of pieces, which are subsequently to be processed into flat sheet, shearing losses may be reduced by suitable correlation of width, thickness, and length. If all other factors which influence the choice of slab dimensions are left out of consideration for the moment, the planning has for its

HOT BREAK-DOWN ORDERS.

TABLE I.

Date....................................

Order No.	Lot No.	Size of Ingots.	Number of Ingots.	Grade of Metal.	Hot Roll to		Run To.	Cut.	Pieces to Slab.	Date Rolled.	Time.	
					Width, In.	Thickness, In.					Start.	Finish.
				Original	and one	carbon.						
				Original	goes to	hot mill.	Carbon	is kept in	Mill Offi	ce as rec	ord.	

STOCK SHEAR ORDERS.

TABLE II.

Date....................................

Order No.	Lot No.	Number of Slabs.	Grade of Metal.	Slab Size.		Cut, Length, In.	Trim.	Pieces.	Weight, Lb.	Date Cut.	Time.	
				Width, In.	Thickness, In.						Start.	Finish.
				Original	and one	carbon.						
				Carbon	goes to st	ock shea	r. Origin	al kept i	n Mill O	ffice.		
				As soon	as lots ar	e finished	carbon a	nd origin	al are fil	ed in Mi	ll Office.	

[3] R. J. Anderson, *op. cit.*

primary object the production of a slab of such area that the maximum recovery of finished sheet will be obtained per ingot—*i.e.*, all shearing losses will be minima. There are necessarily limits to which this can be carried, an important governing factor, other than the relation of ingot size and finished sheet size, being the proper thickness as regards annealing—*i.e.*, the percentage of cold work after an anneal.

slabs may be hot rolled. Aside from the influence of ingot dimensions and the required surface area of the slabs on the thinness, important factors affecting minimum thickness include the final gauge of the finished sheet, intermediate annealings (if any), and the final temper. As is known, aluminium sheet is normally rolled cold, starting with the hot-mill slab. In some plants, slabs from the hot mill may be sent directly to a continuous mill and run down

MILL ORDER TICKET.

TABLE III.

SCHEDULED

Lot No ....
Number of Ingots ....
Slab Weight, Lbs. ....

Date ....
Order No. .... Item ....
Gauge .... Size .... Grade ....
Pieces .... Passed { Pieces .... Weight, Lb. ...... Scrap { Pieces .... Weight Lb. ......
Weight ....
Class ....

HOT ROLL .... No. of Ingots. .... Gauge. .... Width. | .... D .... N .... Workmen. Ingots Rolled. .... Time. .... Date.

END SLAB SHEAR .... Directions. .... Workmen. .... Time .... Date.

SLAB ROLL .... Start. .... Finish. | .... D .... N .... Workmen. Ingots Rolled. .... Time. .... Roll No. .... Date.

SIDE STOCK SHEAR .... Length. .... Width. .... Sheets per Ingot. .... Workman. .... Time. .... Roll No. .... Date.

Furnace No. .... Date .... Time Start .... Time Finish .... Operator .... Temp. ....

ROLL.	Gauge.	Width.	Grade.	Date	Shift.			Workmen.	
					1			Roller	Pieces Lost Cause
					2				
					3			Catcher	Time Lost Cause

Furnace No. .... Date .... Time Start .... Time Finish .... Operator .... T. °F. ....

					1			Roller	Pieces Lost Cause
					2				
					3			Catcher	Time Lost Cause

Furnace No. .... Date .... Time Start .... Time Finish .... Operator .... T. °F. ....

					1			Roller	Pieces Lost Cause
					2				
					3			Catcher	Time Lost Cause

Furnace No. .... Date .... Time Start .... Time Finish .... Operator .... T. °F. ....

					1			Roller	Pieces Lost Cause
					2				
					3			Catcher	Time Lost Cause

Furnace No. .... Date .... Time Start .... Time Finish .... Operator .... T. °F. ....

					1			Roller	Pieces Lost Cause
					2				
					3			Catcher	Time Lost Cause

Furnace No. .... Date .... Time Start .... Time Finish .... Operator .... T. °F. ....

Operation.	Workmen.	Date.	Time.		Pieces Lost.	Remarks.	Operation.	Workman.	Date.	Time.		Pieces Lost.	Remarks.
			Start.	Finish.						Start.	Finish.		
Rough Shear Length							Circling (Blanking)						
Rough Trimming							Flattening						
Finish Trimming							Stretcher						
Finish Squaring							Cleaning						
Finish Splitting							Shearing Coils						
Squaring for Circles							Inspection						

Inspector's Report. Lb. Metal Lost Because Of				Metal Record.		Olsen Cupping Test.	
Dirt		Holes				Depth of Cup, In.	Lb. Pressure.
Blisters		Coil Marks		Gross Weight, Lb.	Heat No.	0.250	
Surface Scratches		Slivers		Stock Shear Weight, Lb.		Breaking Point	
Rolled-in Scratches		Pinched		Finish Roll Weight, Lb.		Scleroscope Hardness	
White Stain		Off Size		Received Inspection Weight, Lb.	Overage		
Brown Stain		Off Temper		Passed Inspection Weight, Lb.	Pieces		
Off Gauge		Pits					
Buckles							

Generally speaking, it is good practice to roll slabs as thin as possible, taking into account all factors which govern slab thickness. The thinner the slab the less the amount of reduction required in cold rolling to gauge. Consequently, the lower the cost of production, since hot rolling can be done much faster than cold slabbing or roughing. There is necessarily a limiting thinness to which at moderate temperature. Thus, slabs for coil production may be run from $\frac{3}{8}$ in. thick to 0·08 in., or from 0·5 in. to 0·1 in.; slabs for flat-sheet production may be run down on a continuous mill from, say, $\frac{3}{8}$ in. to $\frac{1}{8}$ in. thick. In slabbing for flat-sheet production on two-high mills, the stock is run to nominal gauge, the thickness being reduced usually about 50%; subsequently, the material is roughed to within, say, two gauge numbers of the finished gauge. The amount of metal left for the finish rolling

[3] R. J. Anderson, "Aluminium Sheet Production, Part IX.—The Hot Break-down Operation," METALLURGIA, Vol. 4, No. 23, 1931, p. 149.

depends upon the width of the sheet, the final gauge, grade, temper, and other factors. The first roughing on coil corresponds to slabbing on flat-sheet stock.

In determining the proper thickness of the hot-mill slab, important matters for consideration are the final gauge of the finished material and the temper. As is generally understood, full-hard aluminium sheet has been reduced in cross-sectional area at least 75% by cold work, or, say, 12 gauge numbers. Dead-soft sheet is made by annealing full-hard material. Intermediate tempers are produced by cold rolling after annealing, as explained in the discussion of sheet tempers in the first article of this series.[4] In the selection of slab thickness, it is necessary that cognisance be taken of the effect of prior cold reduction on grain size (and, consequently, mechanical properties) following anneal. One critical percentage of cold reduction, corresponding to fine grain size on annealing, is about 75 to 80% of the cross-sectional area. For the same conditions of prior history of the metal and the same conditions of annealing, cold reductions of, say, 55 or 95% will yield very much larger grain size. A relatively small reduction in area by cold rolling prior to anneal may yield material unsuitable for further rolling or final use. Hence, in the planning, where necessary, the slab thickness is so chosen and the subsequent processing so arranged that the metal is not annealed after being cold worked some untoward amount. As an example, supposing it is desired to make 24-gauge, 2SO sheet or coil: The ingots may be broken to slabs 0·4 in. thick; the slabs are next run down to 0·1 in., corresponding to a reduction of 75%, and then annealed; the stock is then further cold rolled to gauge (0·0201 in. thick), corresponding to a reduction of 79·9%, and finally annealed. The matter of proper "annealing points," both as regards the production of fine grain size and intermediate tempers, will be discussed fully in a later article dealing with annealing practice.

Many other important questions are presented for consideration in planning, among which may be mentioned the following: Scrap allowances for rough and finish shearing; cracking tendencies of various compositions, particularly of the heat-treatable alloys; size of lots, corresponding to size of sheets or coils; thicknesses to which slabbed, roughed, and run down; pack rolling; maximum and minimum limitations as to finished sizes and gauges; and limitations imposed by the available equipment. All of these items cannot be discussed in detail here, but, as above mentioned, their relations to the problems of planning will be apparent from the descriptions of the sundry processing operations to be given in later articles.

Tables for Planning.

The paper work of planning can be reduced enormously by the use of convenient tables or charts. Such tables list numerical data which are referred to frequently in figuring orders. By posting these data in permanent tabular form, the necessity for continued re-calculation is avoided, and the planning can be done more quickly. The chances of making mistakes are also lessened. A list of the tables which find most use in the aluminium rolling mill, together with some others, is given below.

Where ingots of various sizes are used in a plant, a table should be prepared giving the dimensions and the corresponding weights. The weights should be averages, obtained by actually weighing a large number of ingots.

Charts, or so-called scales, should be drawn up covering the roll sets to be used in the hot break-down operation. These scales should show the dial settings for each pass in rolling slabs of a wide variety of dimensions from ingots of different sizes.

Various tables applying to slab dimensions will be found useful. Thus, tables may be prepared showing the proper hot-rolling thickness (of slabs) corresponding to a wide range of widths and lengths, as regards ingots of different sizes. Tables giving rectangular areas in square inches and square feet (or in metric numerals), covering the usual range of slab, coil, and finished-sheet sizes, will come in handily. Another useful table applying to slabs is one which indicates the length of cut to be made on rough shearing, prior to slabbing for flat-sheet stock, corresponding to the required length of the finished sheet. This is discussed more fully later (*vide* The Slab Cuts).

A table giving the weight of aluminium plate and sheet in pounds per square foot for the complete range of commercial thicknesses and gauges will be found indispensable. Tables may also be prepared indicating the weight per piece of finished sheet and coils in various gauges, widths, and lengths. Similarly, tables may be prepared showing the weight per piece for circles of various gauges and diameters; the areas of the circles, corresponding to the different diameters, may be incorporated.

Other data which may be arranged in tabular form and which will be found useful in planning include the following: (1) Conversion of common fractions to decimals of an inch, over the range $\frac{1}{64}$ to 1 in., and equivalent millimetres; (2) maximum lengths of coil, corresponding to ingots of given sizes, for different widths and gauges; (3) shearing allowances, as affected by gauge; (4) number of sheets to be rolled per pack, as affected by gauge; (5) allowances for finish rolling—*i.e.*, in thickness, as affected by gauge; (6) average number of passes, in the various cold-rolling operations, to accomplish specific reductions in area; (7) outputs in pounds per hour, as regards the various rolling and other processing operations; and (8) annealing times and temperatures, as affected by load, weight, gauge, size, and method of annealing.

It is, of course, to be understood that certain of the planning data, above indicated, applying to commercial 99+% aluminium cannot apply to alloys such as duralumin. Suitable tables covering the necessary planning information should be prepared, taking into account the special conditions imposed, for particular alloys.

(*To be continued.*)

[4] R. J. Anderson, "Aluminium Sheet Production," METALLURGIA, Vol. 2, No. 12 October, 1930, p. 211.

Journal of the Institute of Metals. Volume XLVI.

A RECORD of scientific papers presented at the Zürich meeting of the Institute of Metals in September, 1931, comprises the latest volume of this metallurgical journal. Numbering twenty-five in all, the papers deal with a wide range of practical and theoretical aspects of modern metallurgy. The first constitutes the tenth annual autumn lecture. Delivered by a distinguished Cambridge scientist Mr. U. R. Evans, it is concerned with corrosion problems. In further papers reproduced in the present volume the authors touch on other aspects of the corrosion problem, including the protection of magnesium alloys—used for aircraft—from corrosion, and the corrosion of early Chinese bronze. Such practical matters as galvanising, annealing, rolling lead alloys, and wire drawing, form the subjects of papers that gave rise to valuable discussions which are now reproduced verbatim—often accompanied by photographic illustrations. How researches that originally were of purely academic interest have developed until they were seen to have an essentially practical application is indicated in the case of two papers showing the manner in which the spectrograph has been applied to the analysis of metals. Scientists of many nations contribute to the present issue, including Professor A. von Zeerleder and Mr. H. C. Kloninger (Switzerland), Mr. C. Blazey (Australia), Professor N. S. Kurnakow, and Mr. N. A. Ageew (U.S.S.R.), and Captain W. F. Collins (Rhodesia), as well as a large number of workers in Great Britain. Edited by G. Shaw Scott, M.Sc., F.C.I.S. 1931. London: The Institute of Metals, 36, Victoria Street, S.W.1. Price 31s. 6d.

The Basis of Continuous Mills for Tube Rolling*

The requirements for the successful reduction of tubes are fulfilled more efficiently by the continuous mill without a plug or mandrel, according to the Report of the Rolling-mill Committee of the Association of German Ironmasters.

IN rolling mills for the reduction of the diameter of tubes, it is essential to maintain the centre line of the tube straight and also to carry out the operation in the least possible time, owing to the proportionately large cooling surface. These requirements are fulfilled most efficiently by the continuous mill without a plug or mandrel, which is to-day mostly employed for reducing the smallest sizes made on mandrels.

Three designs of continuous rolling mills are used at the present time, with essential differences between them. That unsatisfactory results are obtained in some plants and satisfaction secured in others, is to some extent caused by the failure to appreciate the principles underlying the processes.

The oldest construction, and that most widely employed, consists of a mill having 16 to 24 pairs of grooved rolls (duo-stands). The rolls are all gear driven from an underground train of gears, the rolls themselves being set at an angle of 45° to the horizontal, alternately right and left hand, so that each pair of rolls is at 90° to the preceding and succeeding pairs. The reduction of diameter which can be obtained with this type of mill is usually from 60 mm. o.d. to 30 mm. o.d.

In 1903/4 H. Stüting, of Wettin, introduced the second process now employed, although this was not generally known until 1921, when a patent was applied for by A. Papen. Approximately the same number of duo-stands are used in this mill, the difference being that only alternate stands, the odd numbers with horizontal rolls, are gear driven. The even number stands have idle vertical rolls through which the tube is partially pushed and pulled by the action of the gear-driven rolls. Both driven and idle rolls are used for reduction, the total amount of which is similar to that obtained with the first type of mill.

The third construction consists of a mill with 4-roll stands, all of which are gear driven, the openings of the grooves being displaced 45° from those of the preceding stands. This type of mill had already been employed in the forties and fifties of last century at West Bromwich and in Sweden for lengthening tubes over mandrels, but its use for rolling without a mandrel was first made by H. Stüting also. In the case of this mill the diameter of the tube can be reduced from 60 mm. to 16.5 mm., using 16 stands. Recently this type of mill with four grooved rolls has been employed in America for sizing and straightening welded tubes from 16 in. to 26 in. diameter in any gauge up to ½ in. thick, and up to 50 ft. long.[1]

Since, in the reduction of tubes by rolling without a mandrel there is no compression of the material, the volume remains constant. The change in velocity of the respective passes cannot, however, be simply calculated from the reduction in diameter, since this is accompanied by an increase in wall thickness. The reduction in diameter seldom exceeds 4 mm. per pass, being often as little as 1 mm. The decrease in the sectional area on which the extension—and consequently also the speed of the rolls—depends, cannot be controlled exactly, owing to the many factors which both alone and in combination affect the progress of the reduction. As the result of experience, certain average values have been obtained which can be applied to the drafting and gear ratios, but these only hold good for a particular combination of circumstances which it is difficult to ensure in actual working. This is the main difference between the rolling of tubes without mandrels and all other continuous processes in which the section of the material is solid, and is one of the reasons for the many troubles and opposition met with in practice.

The speeds of the different stands are designed to keep the tube always under tension, both on account of the differences in the friction in the grooves and to minimise this increase in wall thickness. The tension calculated from the difference between the entering and exit velocities is never fully effective, owing to slip in the grooves. This slip is, however, much reduced in the case of the four-roll stands. The tension between the different grooves is a vital condition for the shaping of the tube in reducing rolling.

The calculation of the increase in speed can only be regarded as very uncertain owing to the many factors which come into play. The thickness of the tube always increases in rolling steel, but the best results in designing are obtained by calculating on the assumption of constant thickness—the speeds being then proportional to the mean diameters of the tube wall at the respective passes—and adjusting the values so obtained by the use of constants obtained in practice.

With regard to the distance apart of the stands, this is a determining factor on the uniformity of the thickness. As the tube passes through the mill tension is only exercised on it if the velocity of the roll exceeds that of the tube, this tension being cumulative and affecting the length of tube between the respective stands. This causes a variation of the thickness of the tube at both the entering and trailing ends, these not being subjected to the same tension as the middle portion of the tube. The length of tube so affected is obviously dependent on the distance apart of the stands. This question is examined at length in the report, formulæ being obtained for the length of the leading end of the tube, which, so far as this is not made taper to overcome this effect, is thicker than the middle portion. This thickness gradually decreases, more or less in a series of steps, the extent being calculated for a 60 mm. o.d. tube reduced in a duo-mill with 18 stands, of which 16 were reducing stands, to 30 mm. o.d., as from 3·46 mm. thick at the end to 3·14 mm. thick in the middle portion—*i.e.*, 0·32 mm., or 13%.

In the case of the four-roll mill, the difference in thickness between the end of the tube and the middle, for a similar reduction in outer diameter effected in 8 stands instead of 18 was given as only 0·1 mm. Apart from this greater uniformity in thickness, a figure was given showing that a tube having an initial sectional area (metal walls) of 496·6 sq. mm.—*i.e.*, 60 mm. o.d. by 2·75 mm. thick,—when reduced in a duo-mill would have a material section of 303·75 sq. mm., but in a four-roll the area would only be 270 sq. mm. Had the thickness remained constant at 2·75 mm., the area of the metal wall would have been 261·43 sq. mm.

The report also included a lengthy examination of the forces causing elongation and thickening of the tube, showing the better and more uniform results obtained with the four-roll mill. The average reduction of the outer

* Abstract from Report No. 90 of the Rolling-mill Committee of the Association of German Ironmasters. V. *Stahl und Eisen*, November 12 and 19, 1931.

[1] *Iron Age*, January 29, 1931.

diameter was given for the particular tube used as the basis of comparison as 1·5 mm. per pass for the duo-mill, 3·4 mm. per pass for the four-roll mill, and 6·0 mm. per die in the drawing process.

The other requirements for a satisfactory tube mill were considered, these being summarised as follows :—

1. Maximum reduction per pass with minimum increase in thickness of wall and least possible cooling of the tube.
2. Prevention of all slip in the grooves.
3. Suitability for any length and thickness of tube.
4. All rolls to be driven.
5. Least number of reducing passes.
6. Minimum distance between consecutive stands.
7. No springs in the rolls and housings.
8. Exact adjustment of the rolls.
9. Minimum wear of the rolls.
10. Variable adjusting of the speed of revolution of the rolls.

In discussing the report, F. Kocks maintained that it presented the ordinary duo-mill in too unfavourable a light. He especially took exception to the importance attached to tension between the different stands, pointing out that the general effect of passing stock through rolls was that it was retarded and upset at the entrance, but accelerated at the exit, elongation taking place. In the usual mills, reducing a tube from 60 mm. to 30 mm. outer diameter, the increase in wall thickness at the ends was only from 3 mm. to 3·6 mm. He also objected to the suggestion that the force causing thickening of the tube was zero at the root of the groove. With regard to the speed of the stock in any stand, he developed a geometric series thus—

$$V \text{ actual} = V \text{ theoretical} - Ak + Bk^2 - Ck^3 + Dk^4,$$

etc., in which k is the coefficient of slip in each stand. The second quantity in this series represents the influence of the adjacent stand, the third quantity that of the next stand but one, and so on. Since k is very small, probably never exceeding 0·1 to 0·2, the third and fourth powers are negligible, and it is a matter of indifference, so far as the speed of any stand is concerned, whether there are six, twelve, or eighteen stands in front of it.

He also pointed out that in the four-roll stand the central section is circular, but that this does not apply to the section at which the rolls grip the tube on entering. He had had some tubes reduced in a four-roll mill, and on examining the section of the tubes found that these showed four places at which the material had been severely overstressed, totally different from the effect produced in an ordinary duo-mill. With the four-roll mill the tube must be initially round, and matters cannot be improved by altering the shape. On the other hand, with a duo-mill the end can be made oval to ensure uniform stressing of the material in spite of the gripping by the rolls in commencing rolling.

In reply, Lobkowitz said that the experience referred to, which occurred four years ago, was not found with modern mills, the latter giving absolutely satisfactory tubes. It was not right to suggest from these earlier results, still unexplained and not necessarily connected with the rolling process itself, that a definite conclusion could not now be drawn regarding the relative advantages of the different systems. Although only one four-roll plant was in use in Germany, there were a number giving satisfaction in other countries.

In a written communication, K. Grüber also contended that the duo-mill had not been presented to the best advantage, since recent operating results showed a reduced length of thickened tube end. According to him, neither the duo- nor the four-roll mill is able to prevent such thickening of the end if the tube is initially of uniform thickness before being reduced in diameter. He further questioned the value of the four-roll mill in view of the high capital cost.

Lobkowitz, in reply, claimed that the correct comparison of the two systems, accepting the basis of the number of rolls, used by Grüber, instead of the number of stands, was the ratio of the extra thickening of the wall at the end per roll. This was five times as great with the duo-mill as with the four-roll mill, taking it as 0·5 mm. in 16 stands—*i.e.*, 32 rolls in the former case and 0·1 mm. in 8 stands, also 32 rolls in the latter. He had not given the best results obtained with the four-roll mill, which was still in an early stage of development. Not only did these mills enable reduction to be carried to smaller diameters, but the uniform thickness obtained meant a considerable decrease in the use of the expensive drawing process, which more than justified the initial expenditure on the four-roll reducing mill.

British Standards for Milling Cutters and Reamers.

It is interesting to learn that a revision of the British Standards for Milling Cutters and Reamers (B.S.S. No. 122) has just been issued. This publication was first published in 1920 and the comprehensive tables which it embodied covering milling cutters and reamers of all types have been invaluable to manufacturers and users of these tools. The revision was undertaken in order to make certain modifications which had become necessary as a result of changes in practice.

It was considered that a somewhat bigger key was desirable in the case of the larger diameter arbors, and the tables of dimensions for keys and keyways for arbors have, therefore, been amended and extended to provide for arbors up to 5 in. in diameter.

There has been an increasing tendency to use gear-cutter hobs, longer than those specified, particularly in the case of hobs of small diameters, and the table of dimensions of hobs has therefore been revised along these lines. The table of hand taper-pin reamers has also been correlated with the table of dimensions of taper pins in B.S. Specification No. 46, Part 3.

One of the most important features of the revision is the addition of standard dimensions for milling machine spindle noses and arbors of two sizes, together with the dimensions of adaptors for using old-pattern arbors in the new spindles. This extension has been noted by an addition to the title which has now been amended to read "Milling Cutters and Reamers (including Milling Machine Spindle Noses and Arbors)."

Copies of the revised publication No. 122–1931 can be obtained from the Publication Department, British Standards Institution, 28, Victoria Street, S.W. 1, price 2s. 2d. post free.

Recent Developments in Cast Iron.

(*Continued from page* 82.)

pipes in sand moulds. This plant is indeed a challenge to the depression complex. Several foundries have been mechanised to give continuous production, and this process raises many technical and metallurgical problems apart from the purely engineering and mechanical aspects. Perhaps the most pressing problem is that of moulding sand, which has to receive much more care than is necessary in an ordinary jobbing shop. Purchase of the right grade, moisture control, mixing proportions, conditioning and after-treatment, are all important. Foundry interest in sand treatment is growing rapidly, and many installations have been made. This is bound to continue. The development of the oil-sand core also proceeds rapidly, and the effect of advice respecting the design and operation of core stoves for the production of the best oil-sand cores is taking effect.

For the future of cast iron, those who know most about it will be least inclined to prophesy. Its metallurgical possibilities are as yet only dimly envisaged, and much has still to be found out before its behaviour can be explained in every case. This can only be done through research, for only by knowing the precise structure to be expected from a given composition and melting conditions can properties be predicted and equated in any given case to service requirements.

M.V. "C" Aluminium Silicon Alloy

By L. E. Benson, M.Sc.

Aluminium Silicon Alloys have proved to possess such advantages over previously known light alloys that further developments in this field are of special interest. A recent addition to these alloys is discussed in this article.

THE so-called "modified" aluminium silicon alloys introduced during the last decade have proved to have such advantages over the previously known cast light alloys that any further development in this field is of more than passing interest. The alloy designated M.V. "C" represents such a development, and although it has been manufactured by Messrs. Metropolitan-Vickers Electrical Co., Ltd., under their own patent* and for their own consumption for a number of years, has only recently been put on the market.

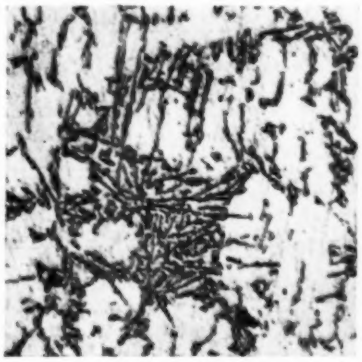


Fig. 1.—Microstructure of Unmodified Al-Si × 100.

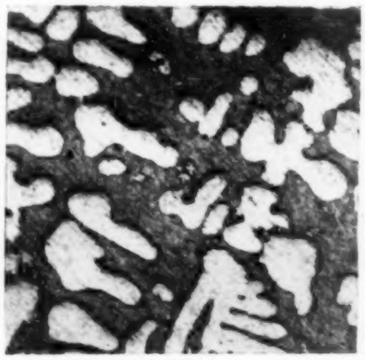


Fig. 2.—Microstructure of Modified Alloy, M.V. "C" × 100.

Fig. 3.—Microstructure of Modified Alloy, M.V. "C" × 400.

A number of the characteristic properties of M.V. "C" and of the three best-known older cast light alloys are given for comparison in Table I. The tensile test figures mentioned are given as representative of what may be expected from good sand-cast bars, and are neither specification figures nor specially picked good results. Also specially heat-treated alloys such as "Y" alloy are not included, since the much-increased cost places them in a class apart. It should be emphasised that the physical properties given are for *sand*-cast bars, and represent, therefore, far more nearly the properties of actual castings than do chill-cast bars which have been so frequently quoted for specification purposes.

TABLE I.

Alloy.	Tensile Strength Tons/Sq. In.	Elongation, %.	Specific Gravity.	Electrical Conductivity.	Thermal Expansion $\times 10^4$/°C	Thermal Conductivity, Cal/cm./Sec.
M.V "C"	10	10	2·68	45	0·217	0·45
2L5 (13% Zn, 3% Cu)	10·5	4	3·1	35	0·255	0·32
2L8 (12% Cu)	9·0	1	2·9	40	0·264	0·38
3L11 (8% Cu)	7·0	2	2·8	40	0·246	0·39
Copper (wrought)	—	—	8·8	100	0·17	0·92
Aluminium (wrought)	—	—	2·7	60	0·25	0·55

TABLE II.

TYPICAL TENSILE TEST RESULTS OBTAINED ON 1 IN. SAND-CAST BARS OF M.V. "C" ALLOY.

Y.P. Tons/Sq. In.	U.T.S. Tons/Sq. In	Elongation, %.	Reduction of Area, %.
5·82	10·02	11·5	—
5·53	9·87	11·5	—
5·72	9·95	9·5	13
4·83	9·6	7·0	13
6·6	9·9	12·0	18
5·35	10·1	9·5	17
5·72	10·17	12·0	12
6·0	10·5	9·0	15
6·16	10·0	7·5	11
5·7	10·1	8·8	12

The tensile strength of 10 tons per sq. in. mentioned for M.V. "C" whilst not the maximum that can be obtained, is suitable for most cast light alloy requirements, particularly as it is combined with very good ductility and toughness. A normal casting, for instance, will withstand considerable distortion by hammering before cracking and breaking, whereas the older alloys are much inferior in this respect. Table II. shows a number of actual tensile test results from pieces machined from 1 in. diameter sand-cast bars. These figures are taken from routine records, and show normal results.

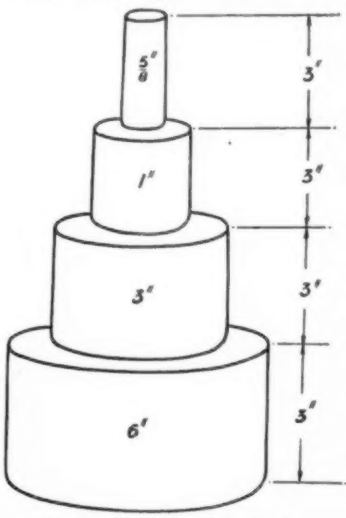


Fig. 4.—Sketch of Test Casting.

Reverting to Table I., it will be seen that M.V. "C" possesses the lowest specific gravity with favourable thermal and electrical properties, compared with the other alloys shown, and has therefore properties of value both to the mechanical and electrical engineer.

It has been inferred above that M.V. "C" is a modified aluminium silicon alloy, and it is to the modifying treatment applied that the alloy owes its success. The refinement of the microstructure which constitutes modification is too well known to require elaborate description, but the efficacy of the new method employed may be judged from the photomicrographs illustrated in Figs. 1, 2, and 3. Fig. 1 shows the normal unrefined structure of a cast Al-Si

*British Patent 305,311.

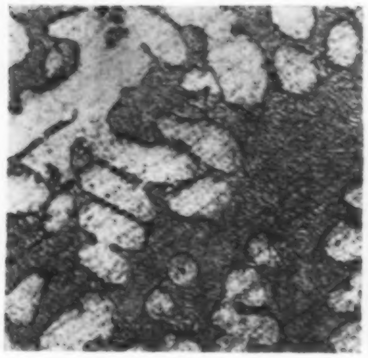


Fig. 5.—Microstructure of Test Casting, $\frac{3}{8}$ in. diam. Portion × 400.

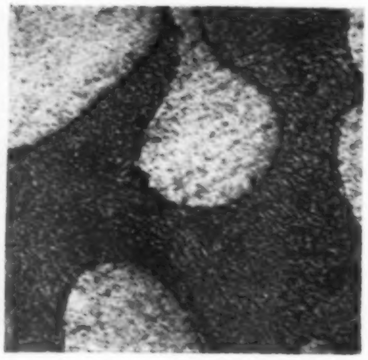


Fig. 6.—Microstructure of Test Casting, 6 in. diam. Portion × 400.

alloy, whilst Fig. 2 is from a sand-cast test bar of M.V. " C " of the same composition and at the same magnification (100). The extremely fine structure produced is better shown by Fig. 3, where a magnification of 400 diameters has been employed.

The uniformity of structure that is possible is well illustrated by Figs. 4, 5, and 6. Fig. 4 gives the dimensions of a cylindrical casting that has been employed for some special tests. The castings varied in diameter from $\frac{3}{8}$ in. to 6 in. They were made in sand without the use of chills or any special precaution, and the test therefore is particularly severe. Nevertheless, the dispersion of the silicon constituent in thick and thin portions was not appreciably different, as shown by Figs. 5 and 6. Furthermore, although no fillet was provided at the changes in section, no difficulty was exprienced due to cracking.

The modified aluminium silicon alloys as a class are probably the easiest light alloys in which to produce sound castings of awkward shape and from the evidence presented above it can well be imagined that M.V. " C " is by no means an exception. Particularly will this be understood when it is mentioned that M.V. " C " is made only from selected raw materials and under controlled conditions in a special foundry. Fig. 7 shows a check-bend test-piece, such as is made for every heat of metal poured.

A good deal has been published recently concerning the defect known as " pinholing," to which cast light alloys generally have proved particularly prone. The defect consists of numerous small round gas holes which are frequently discovered only during machining and whilst for many purposes moderate pinholing is probably of no serious consequence, the appearance of the castings is spoilt and replacement may have to be made. It is worthy of note, therefore, that experience with M.V. " C " has been very satisfactory as regards this defect, probably due both to the method of modification employed and to the strict control of raw materials and procedure exercised in the foundry.

Fig. 7.—Bend Test Piece of M.V. " C " (30713).

Fig. 8 illustrates the extent to which pin-holing may occur. It will be seen that four of the sections of 1 in. diameter sand-cast bars shown are badly defective. These samples were melted in a gas-fired furnace at temperatures varying between 870° C. and 1,200° C., and were not properly modified. The remaining sample, which is quite sound, was modified in the usual way for M.V. " C " alloy after heating to 1,050° C.

As regards resistance to corrosion, aluminium-silicon alloys have come to be regarded as definitely superior to the older alloys under many conditions, as, for instance, for marine service. Fig. 9, for example, shows a serious type of corrosion, in this case on an alloy of approximately

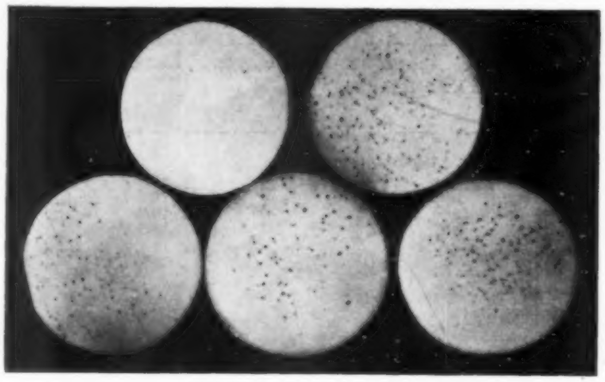


Fig. 8.—Pinholing of Light Alloys.

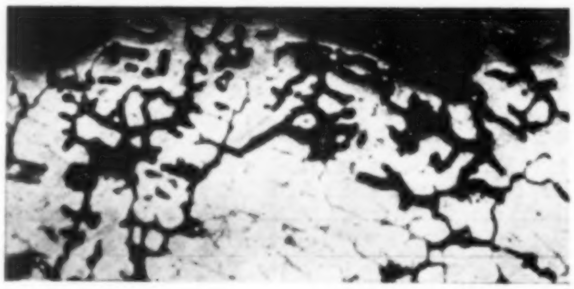


Fig. 9.—Corrosion of Copper-aluminium Alloy × 100.

3LII composition. It is to be noted particularly that corrosion instead of progressing uniformly from the surface is penetrating deeply by electrolytic agency along the network of copper aluminium compound, which is an essential feature of this class of alloy. It may be mentioned that M.V. " C " alloy has been approved by the Admiralty, and many castings have been supplied for service afloat in H.M. Navy.

Faraday and his Metallurgical Researches.

Those who are familiar with the interesting book on " Faraday and His Metallurgical Researches," by Sir R. Hadfield, which was reviewed in the December issue of the journal, will be interested to know that the proceeds from its sale are being used to help the Royal Institution Building Fund, and also to assist various branches of science with which this Institution deals.

Recent Advances in Non-ferrous Metallurgy

The following article is a survey of the metallurgical literature of the last twelve months. In the limited space at the writer's disposal it is alike impossible to cover every investigation of importance or to deal in great detail with any individual piece of work. The main intention is to touch on the most outstanding features of the period under review, and to indicate the trends of advance which have revealed themselves most distinctly.

New and Improved Metals and Alloys.

Beryllium.—The question of new materials naturally comes first to mind. Beryllium, in recent years the focus of such high hopes and of such intensive investigation, has not figured very largely in the literature of the past year. Very recently, however, a paper dealing with the production of the pure metal by electrolysis of liquid ammonia solutions of its salts, which may mark an advance of some importance, has been published by Booth and Torrey.[1] The metal produced is said to be resistant to the action of ordinary reagents (insoluble in HCl and alkali hydroxides, dissolves in *aqua regia* only slowly on heating), but so far it has not been examined in any detail. A small monograph reviewing our present knowledge of beryllium has been published by the Imperial Institute.

Aluminium.—During the year the Deutsche Bunsen-Gesellschaft held a symposium on advances in metallurgy of light metals, and the numerous papers[2] read deserve study.

Among aluminium alloys of interest, the one known on the Continent as Hydronalium (formerly as Magnalium), which contains 7% of magnesium and 0·5% of manganese, is coming into some prominence. Its corrosion-resistance and mechanical properties form the subject of a report by the Deutsche Versuchsanstalt für Luftfahrt,[3] wherein it is claimed that the alloy is extremely resistant to brine corrosion. Another new alloy, Chlumin (containing chromium and a small percentage of magnesium and iron) to which good mechanical properties and corrosion resistance are ascribed, has been the subject of a paper by a Japanese author.[4]

An interesting technique, the "cold-treatment" of Duralumin rivets, is being developed in the United States. It has been shown[5] that the ageing of Duralumin subsequent to heat-treatment and quenching may be retarded by cooling the alloy in ice. This knowledge is now receiving practical application in various American works, in which each day's supply of Duralumin rivets, etc., is kept fit for use (*e.g.*, prevented from age-hardening before fabrication, after heat-treatment and quenching) by storage in solid carbon dioxide-cooled refrigerators at about −1° C. The details of this "cold-treatment" are being investigated by the Aluminium Co. of America and the Dry Ice Corporation.[6]

A survey of the statistical position of the use of aluminium in overhead conductors appears in *Metallwirtschaft*, 1931, 10, pp. 808–809. Figures showing the use of different metals and alloys for this purpose in Germany indicate that from 1926 to 1930 the proportion of aluminium, steel-cored aluminium and Aldrey (aluminium with 0·6% Si, 0·4% Mg., and 0·3% Fe) rose from 27 to 69%. In Europe as a whole, large amounts of Aldrey are now in use, Italy, Switzerland, and Spain leading. The relative merits of steel-cored aluminium and of Aldrey have been debated by F. Giolitti and A. J. Field,[7] while Painton[8] has dealt with the use of steel-cored aluminium.

Zinc and Galvanising.—Based on a study of thermodynamics of zinc smelting reactions carried out by Maier[9], a new process of zinc reduction has been worked out by H. A. Doerner.[10] It is claimed that this process, in which methane or natural gas is used as reducing agent, gives a high-grade metal.

A move towards standardising galvanised sheets has been made by the American Zinc Institute in instituting an official mark, known as a "Seal of Quality," which will give an indication of the weight of zinc coating on the sheets to which the seal is applied (ounces per square foot). Licences for the use of the seal have already been taken out by a number of large firms.

E. J. Daniels[11] has investigated the attack on mild steel in hot galvanising on an experimental scale, and has applied his results to the problem of the life of galvanising kettles. This work gives valuable indications of the conditions under which the maximum life of kettles can be ensured.

The outdoor corrosion of zinc, especially as regards the effect of rainfall and atmospheric pollution, has been examined by W. S. Patterson.[12]

Copper.—The alloys of copper and titanium have been investigated by Kroll[13] and by various American authors. These alloys are heat-treatable; for example, with 3% titanium the tensile strength of the material quenched from 850° C. is stated to be 42·6 kg./mm²., and to rise on ageing for 24 hours at 350° C. to 73·4 kg./mm². (Subsequent cold-rolling raised this value to 113·4 kg./mm².). The electrical conductivity of the quenched alloys increases on ageing, and it is suggested that the alloys with less than 1% titanium may have application as conductor materials. According to Kroll, the elongation of the 3% alloy does not diminish on ageing, a phenomenon apparently not hitherto recorded except in the case of Duralumin.

The alloy Everdur (Cu-Si-Mn, 96-3-1), for which high strength and corrosion resistance are claimed, is receiving a good deal of application in America, and an important paper on its welding properties has been published by Powell and Hook.[14]

Nickel-clad Steel Plate.—An advance of importance for the chemical and other industries is the production of nickel-clad steel plate, consisting of plate $\frac{1}{4}$ in. or $\frac{3}{8}$ in. thick or heavier, with one side coated with nickel, the weight of nickel being 20% of the whole.[15] Nickel-clad steel plate is intended for use in containers, etc., where it will combine the corrosion-resistance of nickel with high strength in a material less costly than pure nickel.

Precious and Rare Metals.—In two papers read before the Chemical Engineering Group, D. McDonald has dealt with the use of silver in chemical plant, and summarised a great deal of information on platinum. A number of papers on silver and its alloys have been published, but no important new avenue for its use, such as might rescue the producers from their economic difficulties, has been discovered. Efforts are being made in various quarters to discover non-tarnishable alloys of silver. The opening of the precious metals refinery of the Mond Nickel Co. at

1 Booth and Torrey, *J. Phys. Chem.*, 1931, *35*, pp. 3,111–3,120.
2 Published in *Z. Elektrochen*, 1931, *37*, pp. 393–762
3 Report "Kf 25/21 II," March 20, 1931.
4 Iitaka, *Proc. Imp. Acad*, Tokyo, April, 1931, *7* (*4*), pp. 161–164.
5 *cf.*, for example, Meissner, *Metallwerlachaft*, 1930, *9*, pp. 641–642.
6 *Metal and Alloys*, 1931, *2*, p. 165; *American Machinist*, 1931, *75*, pp. 439–441.
7 Giolitti and Field, *Metal Progress*, 1931, August, pp. 85–86.
8 Painton, *Electrician*, 1931, *107*, pp. 733–735.
9 Maier, *U.S. Bur. Mines Bull.*, 324, 1930.

10 H. A. Doemer, *U.S. Bur. Mines Rep. Invest. 3091*, April 1931, 14 pp.; *Met. Ind (Lond.)*, 1931, *38*, pp. 499–502.
11 Daniels, *Proc. Inst. Met.*, 1931, *46*, pp. 81–96.
12 Patterson, *J. Soc. Chem. Ind.*, 1931, *50*, pp. 120–123.
13 Kroll, *Z. Metallkunde*, 1931, *23*, pp. 33–34; *Amer. Inst. Min. Met. Eng. Tech. Pub. 432*, 1931; *Metals and Alloys*, 1932, *2* p. 111.
14 Powell and Hook, *J. Amer. Welding Soc.*, 1931, *10*, pp. 39–47.
15 Humpton, Huston and McKay, *Min. and Met.*, 1931 *12*, pp. 90–93.

Acton early in the year was an event of the first importance in the precious metals industry. The largest refinery of its kind in the world, it will produce at full capacity 300,000 oz. of platinum metals (Pt, Pd, Ir, Rh, Ru, and Os) per annum, as a by-product of nickel production.

Reference may also be made to the metals Rhenium and Masurium, discovered as recently as 1925. So far no application of importance has been found, but the number of papers dealing with these metals and their salts shows how eagerly even the most unpromising avenue of future income is explored in these hard times. Among these papers may be cited that of Agte,[17] on the physical and chemical properties of Rhenium, while the literature of both metals is summarised by Tyler,[18] who points out that Rhenium is now available in quantities giving promise of commercial possibilities at a price lower than that of iridium.

Electro-deposited Coatings.—The elimination of porosity from electro-deposited coatings of metals would lead to a wide extension of their application in the chemical industry and elsewhere. The first essential to any study of porosity is the development of sound methods of testing it, and this matter is at present the subject of intensive study. Macnaughtan[21] has published the results of a thorough investigation of methods of determining porosity, in which many kinds of coatings were examined. Very recently Blum[22] and his collaborators at the Bureau of Standards have dealt with the porosity of chromium deposits. They have adopted the copper-deposition method of determination, and have used it for the study of the effect of various undercoats and conditions of deposition.

The number of metals available for deposition is growing steadily. Fink and Jones, in a paper read before the American Electrochemical Society (April, 1931), have worked out a method of depositing tungsten, while Keitel and Zschiegner have communicated to the same society work on the deposition of palladium, platinum, and rhodium.

Alloys for Temperature Service.

Knowledge of the properties of materials at high temperatures is becoming of increasing importance in view of the employment of higher steam pressures in power plant, The utilisation of chemical manufacturing processes involves conditions of high temperature and pressure, etc. A number of papers have been published during the past year, indicating notable advances in our knowledge of this matter. Last June, the American Society of Mechanical Engineers and the American Society for Testing Materials held a joint symposium on the "Effect of Temperature on the Properties of Metals," and the report of this meeting (published in a single volume) comprises a valuable general review of the engineering requirements and the properties of available materials for high and low temperature service. The greater part of this volume is occupied by the discussion of various ferrous materials, but valuable data are put forward concerning non-ferrous alloys, notably in papers by Crawford and Worthington on nickel and nickel alloys, by Templin and Paul on aluminium and magnesium alloys, and by Price on copper alloys.

The determination of the true "creep limit" of an alloy is a matter involving very long periods of time, and while a large number of such long-duration tests are being carried out by many individual investigators, much thought has lately been given to the development of forms of "accelerated" creep tests. Several suggested methods for achieving a satisfactory test of this type are being tried out, and the results are awaited with interest. The National Physical Laboratory are continuing their valuable investigations in this field, and a general review of the present position and of a suggested satisfactory form of endurance testing is given by Batson and Tapsel.[34]

Jenkins and Tapsell have communicated to the Iron and Steel Institute (1931) a paper giving the results of short and prolonged stress tests at 800° C. on nickel-iron-chromium alloys containing minor additions, and have shown that improved resistance to prolonged stress is conferred by the addition of carbon and silicon.

The combined effects of high temperature and corroding media are also under investigation in various quarters, and a thorough investigation of alloys resistant to both heat and sulphur is reported by H. Gruber.[35] For the determination of corrosion-resistance at high temperatures special methods have been worked out in the Krupp laboratories, and these are described, together with furnaces for use up to 1,300° C., by Fritz and Bornefeldt.[36]

Properties of Materials at Low Temperatures.—The mechanical properties of materials at low temperatures are of considerable importance in many ways, particularly in aircraft construction. The properties of various light alloys at temperatures down to – 180° C. have been examined by Bollenrath and Nemes,[37] and the notch strength of Duralumin and Lautal at temperatures down to –190° C. has been investigated by Guldner.[38] Similar investigations are in progress in America, and the U.S. National Advisory Committee for Aeronautics has published a report (No. 358) on experimental determinations of the modulus of rigidity of various alloys used in aircraft instrument construction between – 20° and + 50° C. A technical note published by the same committee (No. 381) gives values for the endurance and other mechanical properties of Monel metal and certain alloy steels at temperatures down to – 40° C.

In the case of tin, with particular reference to tin plate, the most important factor affecting its use at low temperature is the allotropic change of the metal from the white to the grey variety, a phenomenon well known as "tin-pest." This phenomenon has been thoroughly examined by Tammann and Dreyer[39] in relation to the physical condition of the metal and the presence of impurities. These investigations have shown bismuth (0·5%) to be the impurity most effective in inhibiting the change.

(To be Continued.)

Symposium on Steel Castings.

A symposium on steel castings is to be held at the 1932 annual meeting of the American Society for Testing Materials in Atlantic City. This symposium, sponsored jointly by the American Foundrymen's Association and the A.S.T.M., is the second on the subject of castings sponsored by these two societies, the first having been held at the 1931 A.S.T.M. meeting and devoted to malleable iron castings. The purpose in sponsoring these symposiums on castings is to procure and publish authoritative critical data on their engineering properties—data of very great value to all designers, producers, and users of castings which are not now conveniently accessible in any one publication.

An imposing group of papers has been arranged for the symposium. The technical subjects will involve principles of design as related to physical properties; soundness and ease of production; problems in the heat-treatment of steel castings; and test-bar specifications, including the relationship between physical properties obtained from samples and the properties of the metal in the castings. One paper will give general data on steel castings and their fields of application governed by the various physical properties.

It has been agreed to include both carbon steel and alloy steel castings, and data will be included on pearlitic steel castings; on iron-chromium, iron-chromium-nickel and related alloys; and on austenitic manganese steel castings.

16 *Gen. Elect. Review*, 1931, *34*, pp. 10–12, 142.
17 Agte, *Z. anorg Chem.*, 1931, *196*, pp. 129–159.
18 Tyler, *U.S. Bur. Mines Inf. Circ. 6475*, 1931, 17 pp.
19 and 20 *Proc. Inst. Met.*, 1931, *46*, 97–138.
21 Macnaughton, *Trans. Faraday Soc.*, 1930, *26*, pp. 165–181
22 Blum, *Bur. Stand. J. Res.*, 1931, *7*, pp. 697–711.
23 Pullin, *Engineering*, December 19, 1930, *130*, pp. 785–788; *J. Inst. Mets.*, February, 1931, *47*, pp. III–IX.
24 Kantner and Herr, *Metallwertschaft*, 1931, *10*, pp. 717–720, 736–740.
25 Shipman *Amer. Machinist* December 12, 1931, *75*, pp. 708–709.
26 *Amer. Machinist*, 1931, *75*, pp. 278–280, and various papers before the Radiological Soc. of North America.
27 Hessenburth and Bottenberg, *K.W. Inst. Eisenforschung*, 1931, *13 (18)*, pp. 205–213.
28 British Patent 358,697.
29 Eckert, *Giesserei*, 1931, *18* p. 147.
30 Freeman, *Amer. Inst. Min. Met. Eng. Tech. Pub. 391*, February, 1931.
31 Rohn, *Met. Ind. (Lond.)*, 1931.
32 *Heat Treating and Forging*, June, 1931, *17*, p. 559.
33 Rohn, *Z. Metallkunde*, 1931, *23*, pp. 77–86.
34 Batson and Tapsell, *New Int. Assoc. of Testing Materials, Preprint*, Sept. 1931.
35 Gruber, *Z. Metallkunde*, 1931, *23*, p. 151.
36. Fritz and Bornefeldt, *Kruppsche Monatshefts*, Aug.-Sept., 1931, *12*, p. 237.
37 Bollenrath and Nemes, *Metallwertschaft*, 1931, *10*, pp. 609–625.
38 Guldner, *Z. Metallkunde*, *22*, pp. 257 and 412.
39 Tammann and Dreyer, *Z. anorg. Chem.*, 1931, *199*, pp. 97–108.

Rolling Mills and their Lubrication.

RAPID industrial progress in fields of mass production has been the indirect cause for corresponding developments in the art of rolling. Mills are being made larger and are operated at greater speed, but the increasing need for materials suited to specific and individual requirements has directed more attention on research with a view to improving the material and in developing improved technique in manufacturing processes. Special mill lubrication systems, to which comparatively little attention was formerly given, are now being appreciated and are being installed in many plants. The present need for economy in production is gradually being achieved by improving manufacture while at the same time reducing the cost of the various operations.

In regard to mill developments, the paper by G. L. Fisk on merchant-bar mills, presented at the recent meeting of the American Society of Mechanical Engineers, is a noteworthy contribution on the subject. The author deals with the two types of merchant mills which are of particular interest to the modern steel plant—namely, the straightaway continuous mill and the semi-continuous mill. In the last several roll stands of the straightaway mill, the pairs of rolls are alternately vertical and horizontal in order to avoid twisting of the material, and loopers are provided so as to avoid stretching of the material between stands. This type of mill is well adapted for rolling strip, skelp, flats, and angles, but also permits the rolling of other plain sections, including merchant bars. It has the advantage of low first cost and low operating cost.

When using a mill of this type for rolling merchant bars, it is subject to roll-speed control, just as in the case of the ordinary continuous mill for strip or flat stock, but the operator must also contend with additional and superimposed speed changes incidental to section adjustments, and even under the most favourable conditions, the additional burden imposed upon the roller in the case of the straightaway merchant mill is certainly not desirable. Theoretically, it is possible to obtain as accurate a product as that of the semi-continuous mill, but the chances of doing so are fewer.

Generally, it is asserted, the semi-continuous mill is better for high-quality products, also when a great diversity of products must be rolled on one mill, or when the tonnages of the individual sizes rolled are comparatively small. Such mills are more applicable to conditions as they exist in the trade to-day. The straightaway mill has its place in large steel plants, when the work can be selected to suit the mill.

The use and arrangement of vertical mills is considered, also the application of rolling bearings to mill rolls, in the case of existing and new mills, and the economic and practical considerations involved are discussed. Particulars are given of a new transfer table, the rollers of which are operated in the direction of the bar delivery, with the straight rollers running at, or slightly above, the bar-delivery speed. Immediately the entire bar is delivered to the table the rollers are reversed, but a timing relay is provided in the electric control to cause the straight rollers of the table to reverse a second or so later than the tapered rollers. During this time interval the bar in transit will be partly supported on straight rollers running in one direction and partly on tapered rollers running in the opposite direction. The bar, seeking the path of least resistance, will promptly move toward the small ends of the tapered rollers. By this time both the straight and the tapered rollers will be operating in the same direction to deliver it to succeeding mill rolls.

Electrically driven flying shears have been developed during recent years for the cutting of bars up to 4 in. square. A recent development is the use of a flying shear following the finishing stand of a merchant mill, not only to divide the bars into cooling-bed lengths, but also to cut test-pieces from the ends of bars on their way to the cooling bed. It is of the rotary type, and its use facilitates the cutting of test-pieces close to the finishing stand, which permits the roller to gauge the bar without going to the cooling bed.

Cooling bed requirements to meet the needs of various merchant-mill products are also considered, as well as cooling-bed design and operation. A description is given of a recently installed cooling bed which has two sections—a preliminary section for the pack-annealing of squares, flats, and other rectangular sections, and also for the handling of round sections, and a secondary section which provides for the cooling of bars in spaced formation, and also for the packing of rounds. Beyond the cooling bed is the shearing equipment for cutting the cooled mill products to lengths. With double shearing arrangement from a single cooling bed, the bed, table, and shearing equipment can usually be placed over to one side of the mill building, which gives special advantages. The tendency in the modern merchant mill is towards labour-saving and high-grade equipment. Quantity of product is now considered only as far as is consistent with quality, the primary requirement.

Rolling-mill Lubrication.

The development in rolling-mill lubrication during the last fifteen years was discussed by Joseph A. Merrill and Edwin M. May, in a paper presented at the same meeting. The evidence is very conclusive that the continuous oil-application systems that supply the oils for the lubrication of both gears and bearings offer very important economic advantages that can well be considered by all the mechanically equipped industries. In general the use of these modern systems makes lubrication of all large units an orderly automatic engineering function, thereby completely eliminating all dangers due to the careless failure to apply lubricant or to the misapplication of lubricant; eliminates also the dangers of dirt and water contamination of the oil and to damages due to these various causes. The dangers resulting from the use of heavy gear lubricant which has been thinned by the light oil from the bearings are also eliminated, while it prevents undue heating of the bearings, with consequent loss of power through the heavy gear lubricants working into the bearings.

Their use reduces the friction and lowers gear-case temperatures, and consequently the power required for the operation. It is well known that gear friction is almost directly proportional to the viscosity of the lubricant, temperature rise above the room temperature being a true indication of friction loss. Circulating systems will supply oil to the parts to be lubricated at any desired uniform temperature, thereby maintaining the proper oil viscosity for the job.

They also eliminate dirt and gritty material from the bearings, and through continuous lubrication with clean, cool oil, the gears and pinions and all bearings have a longer life.

The cause of costly shut-downs due to machine and part failures is frequently the result of improper lubrication, thus modern systems which eliminate the cause give real economy. The important gears and bearings in many large mills are being adequately lubricated with a total consumption of approximately one barrel of oil per month, indicating savings of 80% against all former methods.

Generally speaking, the high-carbon heat-treated gears that have been properly machined and aligned show little or no wear over long periods when force-feed-lubricated with a clean and cool oil of suitable character. Modern heavy mineral oils, when delivered in volume and at the proper temperature at the point of tooth mesh, have remarkably good cushioning and lubricating properties for gears.

Such oil-conditioning and oil-application systems also provide maximum safety and protection against involuntary shut-downs, and it is for all of these reasons that the modern oil-application systems are in service on the majority of modern ferrous and non-ferrous mills, thus pointing out a very obvious line of lubrication development work for other branches of industry where lowering the costs of operation is desirable.

A New Structural Light Alloy.

*Known as M.G.7, the high tensile and reasonable elongation properties of this alloy are obtained by cold work instead of heat-treatment. It is produced in all the standard wrought forms.**

UNTIL recently structural light alloys, combining high strength with good ductility, owed these properties to some form of heat-treatment, whether in the cast or worked condition. Among the latter class of materials, duralumin has for many years been recognised as an alloy giving high strength/weight ratio, when properly treated. One of the difficulties operating against the more general use of this class of alloys is that they can only be worked in the annealed condition or immediately following quenching, and must always be heat-treated after any appreciable amount of hot or cold work has been done on them, to retain their high mechanical properties. These considerations have led to the development of a new light alloy, M.G.7, possessing high tensile strength and good elongation, obtained partly through cold work instead of heat-treatment, which has recently been marketed by James Booth and Co., Ltd. This new alloy is composed mainly of aluminium in combination with magnesium and manganese in such proportions as to produce a material having a specific gravity of only 2·63, whilst its mechanical properties are similar to those called for by the B.E.S.A. Specifications for the well-known wrought light alloy, "Duralumin." Official specifications are under preparation, and it is expected will be issued shortly.

The most interesting properties of this material are: Firstly, its very high resistance to corrosion, and, secondly, its high mechanical strength. The combination of these two properties make this alloy of conspicuous and outstanding interest and value.

The principal physical properties of this alloy are :—

Specific gravity	2·63
Annealing temperature	380° C.
Forging temperature	400–420° C.
Fatigue range	±9·5–±10·25 per sq. in.
Brinell hardness	90–115
Izod impact value	17 ft.-lb.

The mechanical properties of the material may be briefly summarised by stating that in the rolled form it is stronger than rolled and heat-treated duralumin. In the form of bars and forgings, the strength of the material is not quite so great, being about 2 or 3 tons lower than that of duralumin, whilst in the form of tubes its strength is practically identical with that of heat-treated duralumin. The metal is not capable of heat-treatment, and variations in its strength can only be brought about by the application of differing amounts of cold work.

The results of actual tests taken from the metal in different conditions are as follows :—

	Proof Stress.	Maximum Stress. Tons per Sq. In.	Elongation, %.
Annealed	11	22	20
Rolled or drawn	19	25	12
Hard rolled	25	29	6

The annealed test results apply to material in any of the standard wrought forms. The hard-rolled test values can only be obtained on sheets and tubes of normal wall thickness, but the second set of test values apply to sheets in the ordinary way and to bars of a size not greater than about 2 in. diameter.

Since the material is not susceptible to heat-treatment, such as quenching and ageing, the technique of handling "M.G.7" is rather different from that of handling duralumin. The material in its softest condition has a much higher maximum stress than annealed duralumin or than duralumin immediately after quenching. The application of cold work to the material hardens it fairly quickly, and since the initial strength of the metal is high, the amount of working and shaping that can be applied to "M.G.7" before it becomes too hard is comparatively restricted. Of course, the material can be re-annealed, and worked further, and as it has a very considerable toughness, it can, by suitable means, be shaped quite satisfactorily.

The metal contains no copper, being composed practically entirely of aluminium and magnesium, and consequently it can be welded. The technique of welding is, of course, somewhat different from that of pure aluminium, but anyone adequately skilled in the art can produce satisfactory welds in "M.G.7."

The resistance of the material to corrosion, particularly that of the atmosphere and more especially of sea-water, is extremely high. It is possible to show this by the examination of specimens which have been immersed in sea-water for prolonged periods and the freedom from attack on the surface of the material is extremely striking. It may be stated also here that "M.G.7" is entirely free from liability to intercrystalline corrosion. In order to demonstrate the freedom from attack, it is most satisfactory to quote the results of actual mechanical tests taken upon specimens of the material exposed for various periods to the effects of sea-water. It is well known that the effect of corrosive agents upon metals is to reduce very markedly the elongation per cent. if any corrosion occurs, and usually also to bring about a marked reduction in the value of the maximum stress of the material. In the following table are set out the results of such tests actually obtained by the D.V.L. in Berlin. The figures in question show the effect of the same corroding medium upon "M.G.7," duralumin and soft aluminium, and the singularly high resistance of the "M.G.7" under these conditions is extremely noticeable.

Time of Exposure.	Max. Stress, Tons/Sq. In.			Elongation, %.		
	M G 7.	Dural.	Soft Al.	M G 7.	Dural.	Soft Al.
0	25·5	26·5	5·75	11	18	28
10 days	25·5	24·8	5·73	11	15	27
20 ,,	25·4	23·1	5·61	11	10	23
30 ,,	25·7	22·2	5·52	11	9	21
40 ,,	25·4	21·8	5·40	11	7	19
50 ,,	25·3	21·5	5·35	11	7	17
60 ,,	25·2	20·9	5·35	11	6	16
70 ,,	25·1	20·6	5·30	11	5	15
80 ,,	25·1	20·1	5·20	11	5	12
90 ,,	25·1	20·0	5·12	11	4	11
100 ,,	25·1	19·5	5·06	11	4	10

Further results have been obtained by Messrs. Booths as a result of considerable experimental work, and these are roughly summarised in the following table. Here again the tremendous success with which "M.G.7" is able to resist corrosion is very evident.

Time of Exposure.	Max. Stress, Tons/Sq. In.			Elongation, %.		
	M G 7.	Dural.	Alclad.	M G 7.	Dural.	Alclad.
0	28·5	26·3	25·1	6	19	23
5 weeks	28·2	18·9	24·1	5	4	10·5
10 ,,	28·7	15·7	23·1	6	2	11·0
15 ,,	28·7	13·2	21·5	7	nil	6·5

The material can be produced in all the standard wrought forms—sheet, tubes, strips, rods, extruded sections, rolled and drawn sections, wire, rivets, bars, forgings, and drop forgings. As a result, it is perfectly simple for a complete construction to be made in this material even to the jointing pieces, and, consequently, to avoid any secondary troubles that might be experienced, due to galvanic action as a result of contact with metals of dissimilar values. It has been shown quite conclusively above that this material possesses an extremely high resistance to corrosion, but if it is desired to go still further and apply the process of anodic oxidation, we are able to advise that the material itself is entirely suitable for submission to that particular process, and that its response to the anodic bath is entirely satisfactory and adequate.

* Memorandum No. 50, Intelligence Department, the British Aluminium Co., Ltd.

Recent Developments in Tools and Equipment

Moulding Machines Operated Electrically.

THE application of electricity to moulding machines has not yet received the amount of attention its possibilities warrant, but gradually its advantages are being appreciated, and successful machines are being produced that indicate increased future application for electricity in this field. The recently designed magnetic moulder, patented and built by Messrs. British Insulated Cables, Ltd., Prescot, Lancashire, shows the remarkable progress that has been made in the development of electrical power for machines of this type. In previous designs electric moulding machines always included a motor as a component part, and frequently were combinations of electric and pneumatic, but this new magnetic moulder is 100% electric, and has no motor attachment.

The outstanding advantage of an electrically operated machine is that every machine is a complete unit, and requires neither compressor nor hydraulic plant for its working. The construction of the machine itself is simple; no valves, glands, packings, etc., are necessary, and there are no pits, pipe-lines, or elaborate foundations; thus practically all the disadvantages of air and hydraulic are obviated. The simplicity of construction and installation, together with low power consumption are very important advantages of the magnetic machine.

Power costs are actually so low as to appear almost ridiculous. Where machines of types SS. 324, 486, and 640 are operated to produce moulds at the rate of 30 per hour, the total electricity charge for an 8-hour production is 1·533d. Bigger machines such as the SS. 960 and 1,280 cost 3·066d. in power when operating under the same conditions, and with electricity charged at 1d. per unit. The type number of machines quoted are intended to convey in square inches the maximum box area the machines will squeeze, so that the SS. 486, for instance, will take a box up to 27 in. × 18 in., or its equivalent in area.

Reference to the sectional drawing Fig. 1 and the following description will show that with a magnetic machine power is consumed only during the actual squeeze, which takes 1 to 2 secs. The pattern draw is by gravity on the down stroke. The pattern table A is slotted for attachment of pattern plate, and is also provided with four slots for the stripping pins to pass through. There is a mild steel apron fixed to the pattern table, which prevents any sand getting into and accumulating on top of stripping frame and magnet pot. The outline of the machine is clean, and there are no ledges to cause sand building up. The four guide-rods B are guided in brackets cast in the top of the magnet pot, and they are 6 in. in bearing when at the top of the stroke. These rods ensure accurate and smooth movement of the table, and prevent lateral movement. The upward movement of the pattern table is caused by passing the electric current through solenoid C, which can be made in one or more sections according to length of movement required and convenience in production. The electric current magnetically energises the stationary and moving cores D and E. The moving core, in its attraction to stationary core D, imparts upward movement of the pattern table through the medium of rod F, which is made in Vickers P M G non-magnetic material, while the cores are made in mild steel.

The speed of movement of the pattern table is controlled by dash-pot arrangement G, while the length of stroke is determined by the distance between the moving and fixed cores. This can be varied by raising or lowering the initial position of the moving core and pattern table by means of hand-wheel H. In its upward movement the pattern table also raises the stripping frame I, being attached thereto by lifting rods J. The stripping frame is guided in its vertical movement by two side rods K, which work in brackets cast on the side of the magnet pot. These rods have an oil dashpot which cushions the downward movement of the stripping frame when released. When at the top of the stroke an automatic dog catch engages with a slot in rods K, which hold stripping frame I and moulding box by means of pins L in the top position. Immediately following this action, the pattern table falls, carrying with it the pattern, which is thus withdrawn from the mould by gravity on the down stroke. The fall of pattern table is controlled for speed by the oil dash-pot G. After the mould has been removed the stripping frame is returned to normal position by the release of dog catch through operation of handle at front of the machine. It

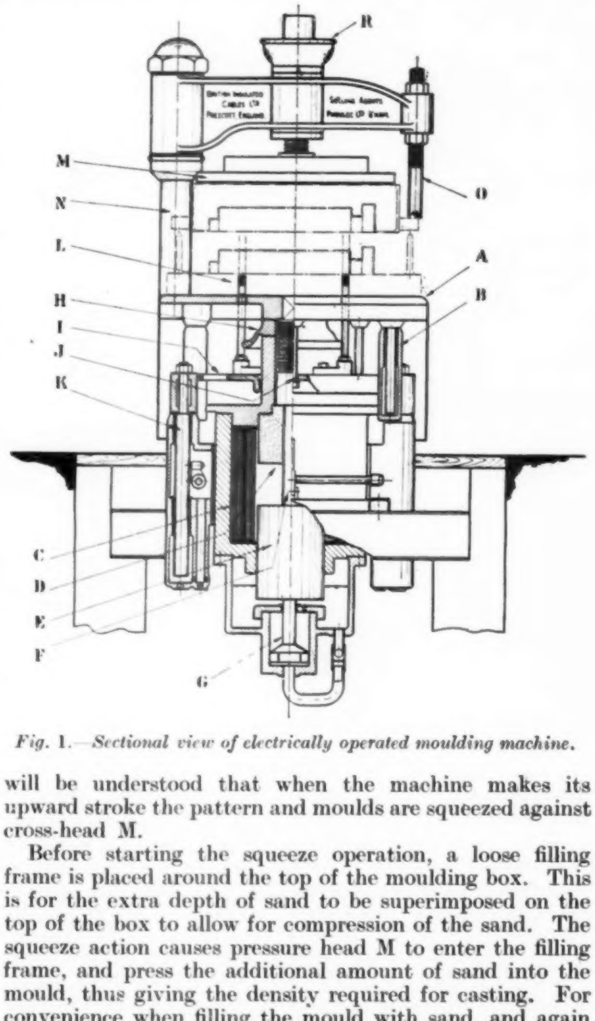


Fig. 1.—Sectional view of electrically operated moulding machine.

will be understood that when the machine makes its upward stroke the pattern and moulds are squeezed against cross-head M.

Before starting the squeeze operation, a loose filling frame is placed around the top of the moulding box. This is for the extra depth of sand to be superimposed on the top of the box to allow for compression of the sand. The squeeze action causes pressure head M to enter the filling frame, and press the additional amount of sand into the mould, thus giving the density required for casting. For convenience when filling the mould with sand, and again when the finished mould is to be removed, squeeze head M is swung by lateral movement around the supporting column N, and placed to the rear of the machine. The pivot of this motion is on a ball-thrust bearing for easy operation, and during the actual squeeze the head is supported by an outer strain rod O. At the bottom of this rod is a fixed collar which engages beneath a projecting jaw

cast integral with the magnet pot and base of machine. It will be noted that in order to accommodate boxes of different depths, the height of pressure head may be adjusted by means of screw P actuated by hand-wheel R.

Magnetic machines are adaptable for use either on plain squeeze, squeeze strip, downs and frame squeeze, and downs and frame squeeze stripping plate work. Four machines operating on downs and frame squeeze stripping-plate method (*British Insulated Patent* 349,173) have just been supplied, and are incorporated in a continuous plant.

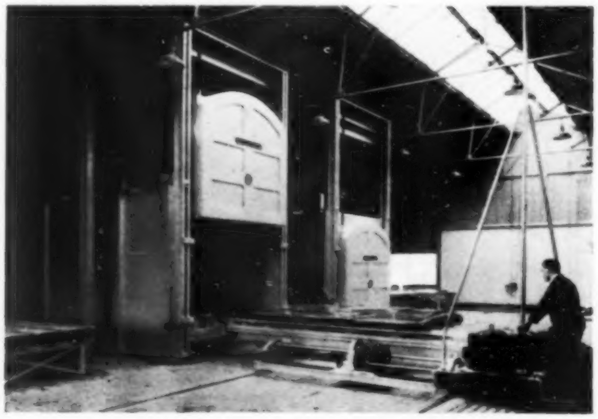
Moulding machine under operating conditions.

We understand that three different type machines will be demonstrated at the 1932 British Industries Fair, squeeze strip, downs and frame squeeze stripping plate, and the new rollover squeeze strip. All machines are built by Messrs. British Insulated Cables Ltd., at Prescot, under their patents 321,777, 322,728, 349,173, 325,453, 355,889, and distribution throughout the British Isles is controlled by Pneulec, Limited, Mafeking Road, Smethwick, near Birmingham.

New Furnaces Installed at Aluminium Works.

The Northern Aluminium Co., Ltd., have recently installed at their works at Banbury three heat-treatment furnaces, two of which are regarded as the largest electric resistance furnaces for heat-treatment so far installed in this country. These two furnaces each have a chamber size of 14 ft. long by 7 ft. wide, and 5 ft. high to the spring of their arched roofs. The third furnace has a chamber 9 ft. 6 in. long by 4 ft. wide, and 3 ft. high to the spring of the arch. These furnaces, which are shown in the accompanying illustrations, are fitted with Wild-Barfield patent centrifugal fans, which, in addition to assisting uniformity in temperature from end to end, decrease the heating time for a charge to attain its desired temperature. Two of these fans are situated in the roof of each furnace: they are mounted on the vertical heat-resisting shafts of bevel reduction gear boxes, which are of special design.

The chambers of these furnaces are lined with Wild-Barfield tunnel bricks, which house thick rod elements in patent hairpin form, the ends of each hairpin being thickened to four times the element area where they pass through the insulation at the back of the furnace to avoid hot connections and loss of power. The side and roof elements are connected up at the back of the furnace to suit the mains voltage, which is 400, 3-phase, 50 cycles, the sides being on one phase, the roof on another, whilst the floor elements, to obviate risk of leakage of current through the charge, are connected to suit a lower voltage obtained by means of single-phase, oil-cooled, double-wound Ferranti transformers, wired to the third phase, making a total delta load of 200 kw. each in the large furnaces, and 100 kw. in the small one, all phases balanced.



Two large furnaces with patent electrically operated charging machine in the foreground.

The floors of all furnaces are provided with longitudinal grooves to accommodate the arms of a Gibbons-Van Marle patent charging machine, which is hand-operated in the case of the small furnace, and electrically driven in the large one. These machines enable a load to be placed in or removed from the furnace in less than 2 mins., with a consequent saving in heat due to doors not being opened for a considerable time, as would be the case if work had to be pushed in by hand. Incidentally, with this machine it is possible to raise or lower the charge gently, reducing wear on the hearth to a minimum. This is accomplished by means of an inclined plane and roller device on the arms of the machine.

Smaller furnace fitted with hand-operated patent charging machine.

All furnaces are equipped with the Foster thermo-electric automatic controls, which operate the coils of the main Brookhirst contactors through a small relay, forming a means of accurate temperature control. The main current to the furnaces is automatically cut off, should the temperature accidentally rise to a value which is likely to cause damage to the charge, or the furnace elements, by means of a thermal fuse, which consists of a loop of fusible wire inserted in the furnace and held by a removable porcelain carrier, forming a readily removable unit. This wire is connected in series with the main contactor coil, so that immediately the wire melts the coil circuit is interrupted, which in turn causes the main current to be cut off. In this same coil circuit there is a Wild-Barfield patent double-pole door switch, having one pole connected each side of the fuse. This removes any risk of shock or short-circuit should the elements or fuse be accidentally touched during charging or discharging. One of these switches is also used to interrupt the fan motor circuit whenever the door is opened, in order that heat may not be lost, due to the heated air being blown out through the open door.

In the case of the smaller furnace, the complete control equipment and transformer are mounted on a platform fixed to the wall above the furnace, and in the case of the larger furnaces, the control equipment for both is mounted on uprights between the furnaces.

It is interesting to note that each door of the large furnaces weighs 2½ tons, the total weight of fireclay and other bricks used in the construction of these furnaces amounting to approximately 24 tons, and the weight of nickel chromium rod-heating elements weighing over ½ ton.

Modern Optical Pyrometers.

Some Details of a notable Design.

OF great interest to the iron and steel and allied industries is the "Foster" optical pyrometer, made by the Foster Instrument Company, of Letchworth, for determining any termperature above, say 700° C. The instrument, which is of the "disappearing" filament type, consists essentially of a light yet robust form of portable telescope containing an electric lamp, the filament of which is rendered luminous by a small portable accumulator carried on a bag with a strap to sling round the shoulder, the brightness of the filament being varied by a rehostat conveniently mounted on the side of the telescope body.

In operating, the user views the filament through the eye-piece, so as to be seen sharply in focus, and then points the telescope at the hot body to be measured, such as the interior of a furnace or a white hot ingot. Next he adjusts the objective or front lens until there is seen in the same field of view the hot body to be measured, with the filament apparently superimposed upon it. By turning the rheostat handle, the brightness of the top of the lamp filament is varied until it just matches that of the hot body, or in other words, "disappears." Finally, the true temperature is then read on an indicator, directly calibrated in ° C. or ° F., mounted on the body of the telescope, the reading, being made at leisure.

All these operations are apparently complicated, but in actual practice readings accurate to 5 C. in 1200 C. are obtained by comparatively unskilled users in less than 30 secs. The standard instrument is of the "Lamp-Bridge Unit" type, an ingenious design in which the lamp filament is made one of the arms of a Wheatstone bridge, the indicator forming the bridge galvanometer, but scaled directly in terms of temperature. Also apart from the extreme sensitivity of this arrangement, of great importance is the fact that the "Wheatstone bridge" and lamp form a single unit which can be removed and a renewal inserted in a few seconds without the necessity of returning the instrument to the factory or disturbing the accuracy.

It will be clear, therefore, that the instrument operates by comparing the intensity of the light radiated from the hot body with that of the standardised lamp. Also there is included a monochromatic red glass which prevents any dazzling effect at temperatures over about 800° C., and also cuts out any colour differences between the hot body, and the filament, thereby ensuring that the comparison is between light intensities, and not colour. In fact, with this system, the pyrometer can be accurately used, even by colour-blind persons.

The standard single-scale ranges are 700-1,200° C., 900-1,450° C., 800-1,700° C., and 1,200-2,300° C., while for temperatures over 1,450° C. and double-range scales, an absorption glass is fitted, the standard double ranges being 700-1,200° C. and 900-1,950° C., 900-1,450° C. and 1,250-2,250° C. A reversing scale 1,200-700° C. and 1,200-1450° C. can also be supplied, and ° F. can, furthermore, be scaled, instead of ° C.

For cases where great accuracy is not necessary, a "simple-circuit" instrument is available, this is generally similar to the standard type, but the Wheatstone bridge is dispensed with, the indicator being in effect a milli-volt-meter, showing the voltage drop across the lamp filament, but scaled in ° C. or ° F.

The "Foster" Optical Pyrometer.

The instruments, which can also be mounted on light tripods for convenience, are of an exceedingly robust character, because the indicators, as with all this make of electric pyrometer, "distance" thermometer, and other instruments, is equipped with the "Resilia" patent spring mounting for the moving coil, balanced between the poles of a permanent magnet carrying the indicating pointer. Essentially, the conical pivots supporting the moving coil have the jewel bearings at the top and bottom connected by a tiny rod which is mounted in light yet powerful springs cut out of thin flexible metal plate, and operated horizontally. As a result, it is impossible for the pivots to "jump" in the bearings, that is become slightly separated by shock or vibration, causing damaged pivots and jewels with the consequent friction and inaccuracy characteristic of many types of pyrometers, the whole arrangement of pivots, bearings, coil and pointer always moving together as one piece.

Index to A.S.T.M. Standards.

The 1931 Index to the American Society for Testing Materials Standards and Tentative Standards has just been issued. It is designed to be of service both to those familiar with A.S.T.M. Standards and those who are not. Its value to the former group is in locating any specification or method of test in the bound Society publication in which it appears. To both groups the Index is a very convenient reference in ascertaining whether or not the Society has issued any standards on a specific subject.

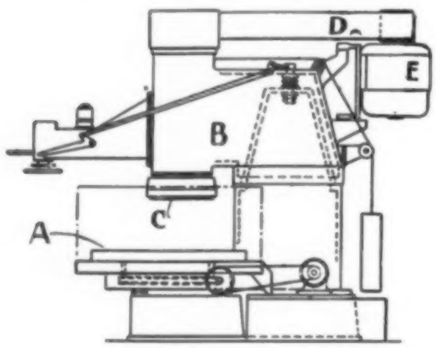
A complete list of the 443 standards and 180 tentative standards herein indexed appears in the 1931 A.S.T.M. Year Book, and in the 1931 Supplement to Book of A.S.T.M. Standards, which publications have been distributed to the membership.

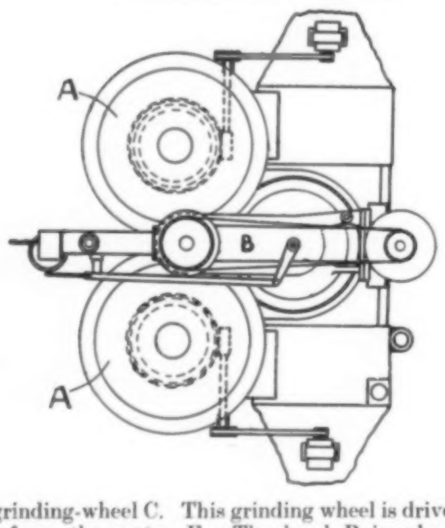
Copies are furnished without charge to those who send a request to the Society Headquarters, 1315, Spruce Street, Philadelphia, Pa., U.S.A.

Some Recent Inventions.

Grinding and Surfacing Machine Tools.

IN grinding, surfacing and similar machine tools, the tables have usually been reciprocated or travelled in a circle or arc to bring either or any of them beneath the overhanging tool-carrying head. A recent improvement in design has been devised in which the overhanging grinding or tool-carrying head is adapted to be swung through an arc to bring it over any one of the work-carrying tables. As a rule, these tables are adapted to revolve about stationary axes, but they may be reciprocated if desired. These improvements are shown in the accompanying illustrations, which show a side elevation and plan of the machine. The work-carrying tables A A are independently revolved about stationary axes by worm-wheels engaged by worms which are driven by belts from separately controlled electric motors. Carried by a column between and to the rear of the tables is an arm or head B, which supports the shaft





of the grinding-wheel C. This grinding wheel is driven by a belt D from the motor E. The head B is adapted to swivel, and is controlled by a bell-crank lever. An ingenious arrangement, when this lever is raised, causes the head-to-head to rise clear of its seat, where it can be swung about the axis of the column to any desired position. Thus, the grinding wheel C can be brought over either work-carrying table, and as the motor which drives it is mounted on the head, the swinging movement does not affect the drive.

The duplex table machine illustrated has the advantage of allowing one piece of work being set up for grinding while work on the other table is being performed, and movement of the tables is unnecessary, since the head can be moved easily. This improvement is also applicable to surfacing or polishing machines, and the overhanging head may be associated with more than two work-carrying tables. Instead of the work-carrying tables revolving about stationary axes, the tables may be adapted to be reciprocated or travelled in an arc or circle about the axis of the grinding or tool-carrying head.

362,750. THE LUMSDEN MACHINE CO., LTD., E. G. BLAKE, W. S. LUMSDEN, and J. H. STAINER, of Gateshead, Durham, patentees. Messrs. Mewburn, Ellis and Co., agents, 70-72, Chancery Lane, London, W.C. 2. Accepted December 10, 1931.

Heat-treatment of Rails.

MANY methods are adopted with the object of preventing permanent strains in massive bodies of metal during the time of cooling, but difficulties are experienced with certain types of work that is rapidly cooled by quenching. Thus, when a rail is subjected to a rapid cooling operation, marked differences of temperature are produced between different parts of the rail metal, particularly between the interior and exterior of the head, which produce strains likely to result in permanent weaknesses if the rail is allowed to cool in the usual way. In order to prevent these strains from resulting in permanent defects, an improved process has been devised for the treatment of a rail or other massive steel body. The process consists in immersing the rail, which has previously been quenched below the critical range so that marked temperature differences exist, in a highly heat-conductive medium at a temperature above the blue-heat zone, but below the critical range to reduce the temperature differences quickly.

A rail 39 ft. long and weighing about 130 lb. per yard, is taken as an example. Such a rail has a composition within the following ranges :—

Carbon.	Manganese.	Phosphorus.	Sulphur.	Silicon.
0·62	1·32	0·023	0·044	0·16
0·72	1·43	0·022	0·042	0·19
0·68	0·72	0·023	0·062	0·13
0·72	0·79	0·024	0·060	0·19
0·74	0·69	0·023	0·049	0·26
0·86	0·81	0·023	0·057	0·22

After being produced in the mill, the rail is allowed to cool from the mill heat until an edge of one of the flanges becomes magnetic ; at this stage, however, the greater mass of the rail is still above the critical range of temperature. In this state the rail is water quenched for 30 secs., and is then transferred and immersed in a bath of molten lead having a temperature of about 540° C., in which it remains for about 4 or 5 mins. From the lead bath it is immediately removed to a closed furnace, which is maintained at a temperature approximating to that of the lead bath, where it is retained for a period of one to one and one-half hours, and when taken from the furnace is allowed to cool in the air.

This treatment of the rail comprises, first, rapidly cooling the greater part of the rail metal through the critical range of temperature ; second, the rapid reduction of temperature differences in the rail in the lead bath ; third, drawing the metal in the furnace in order to produce a sorbitic or troostite-sorbitic microstructure in the hardened metal ; and fourth, cooling the rail to atmospheric temperature.

It is claimed that the immersion of the rail in the lead bath eliminates or substantially reduces the temperature differences in the head, while a considerable mass being still above the heat zone greatly diminishes the chances of permanent defects from strains produced.

Instead of transferring the rail to a furnace from the lead bath, the process may be modified by effecting the tempering operation in the lead bath instead of in the furnace, providing the immersion in the lead bath is prolonged sufficiently to effect the tempering operation. The periods of time for rapid cooling, lead-bath treatment, and tempering will vary somewhat with the particular section and weights of metal treated.

362,439. THE BETHLEHEM STEEL COMPANY OF U.S.A. Messrs. WHITE, LANGNER, STEVENS, PARRY AND ROLLINSON, agents, 5-9, Quality Court, Chancery Lane, London, W.C. 2. Completed December 4, 1931.

Business Notes and News

Mechanical Inspector Rejects Faulty Material.

Flaws of even microscopic size are discovered by the "eye" of a new inspection device perfected at the University of Michigan, which not only finds them in less than one ten-thousandth of a second, but remembers them until a complete examination has been made and the faulty product shunted into discard. This mechanical inspector was developed by Professor Floyd Firestone for the University Department of Engineering Research.

In operation it is swift, sure, and not very complicated. The object to be examined, any piece of metal polished enough to reflect light well, is held in a clamp and revolved. As it revolves it also passes under the lens of a microscope, the light from the metal surface passing through the microscope to a diaphragm which takes the place of the eye-piece, and is pierced by a slit an eighth of an inch long and a few thousandths wide.

This tiny beam of light falls upon a photo-electric or selenium cell, the latter having the peculiar habit of changing its resistance to the passage of electricity when affected by changes in light intensity. If a flaw or crack appears on the product being viewed by the microscope lens, it at once alters the quantity of light from this area, and this is noted or "seen" almost instantly by the photo-electric cell, which experiences a change in the current passing through it.

The cell will react to a change in one ten thousandth of a second, but this is too short to operate relay switches to turn the faulty material into discard, so a "memory" had to be devised. This took the form of a gas-filled radio tube which came into action when the fluctuating current from the photo-electric cell was amplified and passed through it. Current from this tube actuates a magnet, which in turn sets the apparatus for automatic discard. The discharge in the gas-filled tube continues, once started, thus remembering the flaw by keeping the discard path open. Once the inspection of the whole piece is completed, it is shunted aside and the memory tube reset automatically for the coming of the next piece.

Although the new inspecting device is especially rapid in examination of round objects, such as automobile pistons, which can be revolved and moved forward at the same time, it is claimed that it may also be used on any object with a light-reflecting surface, such as sheet tin, as well as being adapted to do various sorting jobs.

Institutes Postpone American Meeting.

In view of the disturbed economic and financial conditions prevailing in Europe and America, particularly the unfavourable rate of exchange, the Councils of the Iron and Steel Institute and the Institute of Metals has found it necessary to postpone the 1932 American meeting, which was to have been held in the United States and Canada next autumn. This meeting had been planned by kind invitation of the American Iron and Steel Institute, and the American Institute of Mining and Metallurgical Engineers.

The suggestion that the meeting be postponed was sympathetically received in America, and the assurance has been made that a meeting will be welcome at such later date as may be convenient.

Alternative arrangements to be made for the autumn meetings this year of each Institute will be announced as soon as possible.

Soda Ash as a Desulphurising Agent.

Many letters have been received, drawing attention to an error contained in the short article under the above heading, published in the December issue. In ordinary foundry practice desulphurisation is effected by placing the required amount of soda ash on the bottom of the ladle, and then tapping out the metal from the cupola at as high a temperature as possible. The main reactions involved may be represented by the following equation :—

$$\underset{\substack{\text{Sodium}\\\text{Carbonate}\\\text{(soda ash)}}}{Na_2CO_3} + \underset{\substack{\text{Manganese}\\\text{Sulphide}\\\text{Iron Sulphide}}}{\frac{MnS}{FeS}} = \underset{\substack{\text{Sodium}\\\text{Sulphide}}}{Na_2S} + \underset{\substack{\text{Carbon}\\\text{Monoxide}}}{CO} + \underset{\substack{\text{Sulphur}\\\text{Dioxide}}}{SO_2} + \underset{\substack{\text{Manganese}\\\text{Iron}}}{\frac{Mn}{Fe}}$$

which should be used to displace that previously published. Will readers please note and rectify this equation.

Coal Gas for Motor Transport.

The successful use of coal gas as a fuel for motor-vehicles is receiving the attention of the research department of the Birmingham Corporation Gas Department. Restrictions on petrol for a short time during the war period focused attention upon coal gas as a substitute, and much commercial transportation was effected by this fuel. The initial means of carrying the gas, by means of large bags on the roofs of the vehicles, quickly gave way to neater and stronger methods of carrying it, particularly in motor-cars, and special metal containers were in use when the restrictions on petrol were removed. The use of coal gas was not continued long after petrol became available, and the reason is fairly obvious. The driving power and cleanliness of coal gas for this purpose are certainly important, but its distribution in as convenient a way as petrol is a much more difficult problem. Much of petrol's popularity is due to its convenient distribution, and any research on coal gas as a substitute should embrace distribution, as well as calorific value and other technical problems, connected with its application for this purpose.

Institute of Metals Report Increased Membership.

It speaks well for the progressive attitude of the Council and members that, in spite of the difficult economic conditions that have prevailed throughout the world during 1931, the Institute of Metals finished the year with a net gain in its membership of 72—as compared with a net gain, in 1930, of 38,—thus making the total membership 2,232, which is the highest figure ever recorded.

The Secretary, Mr. G. Shaw Scott, informs us that on January 21 an election of members is to be held. Members then enrolled will have the privilege of membership, not for the usual twelve months, but for the extended period ending June 30, 1933. It is confidently anticipated that a large accession to the Institute's membership will be recorded. Intending members should make early application to the Secretary of the Institute, 36, Victoria Street, London, S.W. 1.

Decimal Coinage.

The directors of the Manchester Chamber of Commerce have made representations to the Chancellor of the Exchequer concerning the possibility of introducing a reform of British coinage, with a view to the incorporation of the decimal and binary system. It is considered that this particular reform might become a valuable step in measures which, taken as a whole, will constitute a reorganisation of our internal and external financial machinery.

It is considered that there is a definite handicap to British trade in the retention by this country of an antiquated system of coinage, as opposed to the more efficient decimal system of coinage employed by all our foriegn competitors, and the members of the board feel that when other and larger changes are being made, this reform might be effected with even greater convenience than in ordinary times.

The Board has had detailed proposals placed before it by one of its own members, Mr. Harry Allcock, who has devoted special study to this matter, and whose commercial experience qualifies him to formulate an opinion. Mr. Allcock's proposal, in brief, is that the existing values of the £ and the shilling should be retained, but that the shilling should be divided into ten pence instead of twelve. The suggestion is explained and amplified in a paper recently delivered by Mr. Allcock to the Manchester Society of Chartered Accountants.

Diesel-electric Rail Car.

The recently-completed Diesel-electric rail car, built by Armstrong-Whitworth and Company, has been given a further trial on the London and North-Eastern Railway. With a trailer attached, making a 27-ton haul, the speeds were: level 50-55 m.p.h., 1-in-200, 41 m.p.h., and 1-in-100, 30 m.p.h.

With a seating capacity of 60, and a trailer of 90 seats, the accommodation is quite adequate to normal demands. Between the engine compartment, which has a removable roof, and the passenger compartments is a good-sized baggage room. The construction is of steel, and the car is well ventilated, pleasantly decorated, and comfortably upholstered, with wide plate-glass windows giving easy and uninterrupted views of the scenery. Much interest is being taken in railway circles in the experiments with this car, which is the first of three to be completed, and it is shortly to be handed over to the railway company for extended trials in the north-eastern area.

Business Notes and News—continued.

Stainless-Steel Aeroplane.

Stainless steel has now become a recognised material for many aeroplane fittings, but, shortly, an aeroplane wholly composed of stainless steel will be produced in this country.

The advantage of stainless steel construction in a land aeroplane is the saving in cost of reconditioning. The cost of overhauling the structure of an ordinary steel aeroplane is often very high. The stainless steel used for spars, rib profiles, and bracing does not need enamelling, but is treated with clear varnish, so that external inspection immediately reveals any failures due to over-stressing. Spar construction is made the easier by the fact that stainless-steel strip in the heat-treated condition is now available.

Depressing Trade Returns.

The trade returns indicate all too clearly how much the world depression has interfered with Great Britain's trade during 1931. The accounts show a considerable less in the balance of trade, when imports and exports are compared; it is given as £408,975,455. Normally, at least for many years past, there has been an adverse balance between imports and exports, but earnings from shipping and banking business, together with interest on investments abroad, usually more than compensate. Last year was the first since the war that an adverse balance was actually experienced.

It is remarkable that not a single export classification in the Board of Trade returns shows an increase, and the reduction in articles wholly manufactured amounts to just under £150,000,000. Among the largest declines are: Iron and steel manufactures, £20,850,934; vehicles, including locomotives, ships and aircraft, £22,574,478; non-ferrous metals and manufactures, £5,102,933; machinery, £4,134,799.

From these figures, it can readily be assumed that industrially the past year has been one of the most disastrous experiences in Great Britain. Certainly, few connected with the iron and steel trades will regret tha passing of such a year, because it has presented unparalleled difficulties, and, looking back, it becomes a matter of surprise and congratulation that few have crumpled under the phenomenal stress. It is encouraging, however, that December imports totalled £77,027,303 against £83,231,443 in November and £89,657,518 the previous December. Another encouraging fact is that exports increased during the month by £213,976 to £32,077,425.

Electricity and New Industries.

The economic potentialities of South Wales and South West England should be studied, said Mr. Frank Hodges, a member of the Central Electricity Board, at a meeting of the Western Section of the Institution of the Electrical Engineers, held at Cardiff recently. Such a study, he said, would show that there was a demand for services and commodities so diversified and so strong that it would justify the creation of a whole series of new industries for this purpose alone, and in this work the National Power Scheme could play an important part. There were many important developments in rural electrification which might have an important influence in changing the position of South-West England, so that, while he had laid emphasis on the industrial aspect, he had not kept altogether out of sight the very great possibilities which were still to be developed in agricultural and rural electrification. The development and rapid extension of our oldest and most important industry, agriculture, was now likely to go ahead, and in this field supply undertakings were proving themselves capable of vision and very real enterprise. The two districts which had been most receptive were Scotland and the West Country, districts which had been most successful in meeting the depression in agriculture, and in realising even a slight margin of profit.

Steel Workers' Scheme.

The continued depression in the iron and steel industry is causing grave concern amongst the workers, and the Iron and Steel Trades' Confederation is launching a campaign designed to call the attention of the public and the Government to the dangers which are inherent in the existing circumstances. The Confederation devised a scheme for the reorganisation of the iron and steel industry. This scheme was issued at the end of June last year, and embodies the idea of the formation of public utility corporations in each of the great producing areas, controlled by a central board on which there should be Government representation.

The Confederation has admitted the necessity for protection for the industry, but adopts the attitude that its support of such a policy can only be given if the Confederation's scheme of reorganisation is adopted.

The Fuel Research Report.

The Fuel Research Board has issued its Report for the year ending March 31, 1931. The greater attention which has been given to various processes of coal carbonisation, in which the Board is interested, is indicated by the space given to the subject in the report. When the last report was issued, it was thought that sufficient progress had been made with the development of low-temperature carbonisation that experimental work in the development of full-sized retorts was no longer justified, and that work should be concentrated on the utilisation of tars produced. Since the closing of the plant at Richmond gasworks, however, the question has been reconsidered. Many difficulties inseparable from investigations of this character in the first commercial working of the new system arose, the most serious of which was the distortion of the cast-iron retorts. In consequence of partial failure of the plant from this cause, work has again been concentrated on the design of the retorts and the further development of the process, the Board considering that the work at Richmond had been inconclusive. A brick retort has been developed, instead of cast iron, with very promising results, and it is proposed to erect two new retorts of this type with the object of obtaining data regarding their life and cost of working.

Much investigation was undertaken during the year on the products from the process, such as the conversion of the tar into oil and motor spirit, but the work is not yet sufficiently far advanced to report progress. The report includes the results of tests carried out on a Ricardo oil engine using low-temperature spirits from various coals.

Institute for Industrial Fellowship Established.

Dr. Edward R. Weidlein, Director, Mellon Institute of Industrial Research, Pittsburgh, Pa., has announced that the Lukens Steel Company of Coatesville, Pa., has established in the Institute an Industrial Fellowship whose purpose is the scientific investigation of processes employed in the manufacture of steel plates.

Erle G. Hill, who received his professional education at the University of California, has been appointed to the incumbency of this Fellowship. He is a specialist in iron and steel technology, who was previously associate professor of Metallurgy in the School of Mines of the University of Pittsburgh.

Personal.

Mr. F. S. Sinnatt, F.I.C., has been appointed Director of Fuel Research under the Department of Scientific and Industrial Research. Dr. Sinnatt has been Assistant Director of Fuel Research since 1924. Previously he was Lecturer on Fuels in the University of Manchester Faculty of Technology and Director of Research to the Lancashire and Cheshire Coal Research Association.

Mr. J. M. Ormston, M.B.E., has been appointed a special director of Vickers-Armstrongs, Ltd. He will be in charge of the Shipbuilding Department at Barrow, directly responsible to Mr. J. Callander.

Mr. R. L. Smith has decided to discontinue his services with Vickers-Armstrongs, Ltd., with whom he has held the position of chief metallurgist at Erith for the past twenty-two years. He proposes to open an office in the coming year as consulting works metallurgist and inspector.

Interim Dividend.

The Electric Furnace Co., Ltd., of 17, Victoria Street, London, S.W. 1, has recently paid the half-yearly interim dividend for the six months ended September 30, 1931, at the rate of 7% per annum, less tax, in respect of its cumulative preferred ordinary shares.

Some Contracts.

The Darlington Rustless Iron and Steel Co., Ltd., Darlington has placed an order with Fraser and Chalmers Engineering Works (Proprietors: The General Electric Co., Ltd.), Erith, for a "Bliss" Cluster rolling mill. This mill is for the cold rolling of stainless iron sheets up to 48 in. wide, and is being installed to produce sheets of a highly finished quality.

Messrs. Birmingham Electric Furnaces, Ltd., inform us that they have received an order for thirty-seven electric heat-treatment furnaces of various types for export to Russia. This is believed to be the largest single order for electric furnaces ever placed in this country.

The Fairey Aviation Co., of Hayes, Middlesex, have received an order from the Belgian Government for military 'planes for the Belgian Air Force. This order, which provides for the construction of about sixty aeroplanes of two types, is valued at about £300,000. Both types are of all-metal construction, and are equipped with Rolls-Royce Kestrell II engines.

C. A. Parsons and Co., Ltd., of Newcastle-on-Tyne, have recently received an order for three transformers, each of 6,000 kv.a. capacity, with a voltage ratio of 13,500/3,000, and for twenty-six auxiliary transformers of lower voltage ratio, to be used in connection with the new Dunston power station.

Sir W. G. Armstrong, Whitworth and Co. (Engineers), Ltd., has received an order from the Gaekwar-Baroda State Railways, for four Diesel-electric rail cars for 2 ft. 6 in. gauge. The bodies of the rail cars will be built in India to the railways' own requirements, and the rail cars are each intended to haul two trailers.

Messrs. Blackstone and Co., Ltd., Stamford, have received an order for the supply and erection of the whole of the machinery for pumping crude sewage and storm water at the Sneinton pumping station, Nottingham.

The General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C. 2, has received an order from the London, Midland and Scottish Railway for the electrical equipment—on the Oerlikon system—of the new rolling stock required for the augmentation of the services on its London electrified lines—viz., Euston-Watford and Broad Street-Richmond. The order includes the whole of the traction motors, control equipment, and heating and lighting equipment for thirty-one coaches, together with a further quantity of traction motors and additional spares.

The British Thomson-Houston Co., Rugby, has secured an order from the London Midland and Scottish Railway Co. for six 1,500 kw. rotary converters, with starting panels and transformers.

The Hackbridge Electric Construction Co., Ltd., of Walton-on-Thames, has received from the County of London Electric Supply Co., Ltd., an order for transformers for installation at the Barking generating station. The order consists of a number of station transformers up to 10,000 kv.a. capacity and two transformers, each of 93,750 kva. electrical rating, equivalent to 125,000 h.p., three-phase, 50 cycles, 12,500/33,000 volts, B.E.S.A. rating.

Messrs. Ruston and Hornsby, Ltd., Lincoln, have received an order from the Russian Government for 100 vertical oil-engines.

Messrs. Lobnitz and Co., Renfrew, have been awarded a contract for a tug by the Bluff Harbour Board, New Zealand. The value of this order is stated to be about £32,000.

Brook Marine Motors, Ltd., of Lowestoft, has received from the Port of Piræus Authorities an order for a batch of that firm's 15/40 h.p. six-cylinder marine motors, for immediate shipment to Greece.

Messrs. W. T. Nichols and Co., Gloucester, have received a contract for the erection of the West Regional Broadcasting Station at Washford Cross, Watchet, Somerset, the value of which is about £50,000.

Harland and Wolff, Ltd., have received an order for the construction of a cargo and passenger steamer for the Bombay Steam Navigation Co., Ltd. The new vessel, which will be about 230 ft. in length, will be laid down at the company's Govan Yard.

The British Thomson-Houston Company Limited, Rugby, has received an order from the London, Midland and Scottish Railway Company for six 1,500 kw. rotary converters, with starting panels and transformers. These machines are required in connection with the increased traffic on the Euston to Watford line; each will be rated at 1,500 kw., 630 volts, 25 cycles, 500 r.p.m. The firm has also received an order for the reconstruction of three rotary converters at Cheapside sub-station at Birmingham, with alterations to the existing E.H.T. switchgear and automatic control gear, and the modifications of three rotary converters and transformers at Court Road sub-station in that city.

The Great Western Railway have placed with Messrs. Vickers Armstrongs Ltd., an order for five "Norfolk" spades. These appliances, which are the invention of Mr. T. L. Norfolk, the Engineer-in-Chief of the Mersey Docks and Harbour Board, are for use on the coaling plants in the Great Western Railway Docks at Cardiff, Barry, Newport, Swansea, and Port Talbot.

The object of the "Norfolk" spade is to facilitate the clearance from coal wagons of small coal or "duff," which usually does not flow easily when the wagon is tipped. At Port Talbot the appliance will be used in connection with a coaling belt conveyor; at the other four docks it will be used in connection with hydraulic hoists.

Catalogues and Other Publications.

After long experimental and research work, the Consett Iron Co., Ltd., has produced a copper-bearing steel with superior corrosion-resisting properties. It is a commercial carbon steel, manufactured with selected materials under special conditions, carrying a percentage of copper to give effective corrosion-resisting properties. It has been given the brand "Bearco" and the company has published a brochure giving particulars, which will be available on application to the offices at Consett.

A very interesting and informative brochure has been received dealing with the calorising process. All metals oxidise or scale, to a varying degree, under the very high temperatures obtained in the common industrial heating operations, such as carbonising, annealing, and heat-treatment processes, glass manufacturing, oil cracking, steam raising, enamelling, etc. This results in frequent replacements, which may involve the shutting down of plant, with its consequent loss in production. Calorising is a relatively inexpensive preventative, and all interested in heat oxidation problems should read the information given in this brochure, which can be obtained from the Calorising Corporation of Great Britain, Ltd., 32, Farringdon Street, London, E.C. 4.

The Electrical Equipment and Carbon Co., Ltd., Bank Buildings, 107-111, New Oxford Street, London, W.C. 1, have sent us a pamphlet giving details of the new Crosby Type Wire Rope Clips, which have just been marketed. They have drop-forged mild steel bodies, and U-bolts of mild steel. The company inform us they will be pleased to send details or samples to any interested.

"The Sulzer Technical Review," No. 3, 1931, describes in detail the new double-acting Sulzer two-cycle Diesel engine, while other principal articles are included dealing with centrifugal pumps for marine purposes, and investigations on the natural circulation of water in Sulzer super high-pressure boilers.

We have received an informative brochure from Metropolitan-Vickers Electrical Co., Ltd., containing particulars of their single-phase motors and starters. There are specially designed starters suitable for every purpose to which this wide range of motors can be applied. Those interested should send for a copy of Special Publication No. 7022/0 to the company's offices, Trafford Park, Manchester.

The Iron and Steel Trades.

SEASONAL influences during the past month have had their normal quietening effect on the iron and steel trades, but there are now indications that the volume of business in most sections is getting back to something like what it was before the slackness set in.

The improvement in trade that had been experienced in the closing months of last year, due to the departure from the gold standard in September, had been reflected mainly in the foundry iron trade, and relatively good contracts for delivery over the concluding three months of the year had been placed. Delivery specifications against these had been received by ironmasters in reasonably good volume, and the quantities taken into consumption represented a bigger aggregate tonnage than for some time previously. It was known at the time of the buying movement in late September and October that some proportion at least of it had been in the nature of covering operations against a possible rise in values. This, however, did not mature, and the immediate likelihood of an advance seems to have faded away.

On the assumption that some of the iron had gone into stock rather than into direct use at the foundries, sellers of pig iron were inclined to the view that the opening months of the new year would witness a slackening off not only in new business, but also in the rate at which deliveries were specified. Certainly, up to the present, fresh contract commitments have been on a somewhat limited scale in most centres, although it is early yet to expect anything else. On the contrary, deliveries against specifications have been resumed on a fair scale, and the leading producers of foundry iron regard this as a satisfactory development. In the Lancashire district, the improvement in consumption has been largely in connection with the light castings industry, with textile machinists in some departments taking slightly improved quantities. In the Midlands area also the major improvement has been in light castings, and there are hopes that under the new financial conditions the improvement in this respect will turn out to be more or less permanent. A good proportion of the output of some of the leading iron producers is going into consumption at associated foundries. In many centres, of course, notably on the North-East Coast, aggregate production is on a reduced scale, judged by normal standards. At the moment, however, the tonnage available for the open market is readily absorbed, and stocks are being reduced.

In finished iron, trade in crown and lower quality bars continues disappointing generally, and in almost all districts complaints regarding the poor business that is being done are rife. Prospects in respect of the best qualities, however, are rather brighter, and hopes of an improved business consequent on a resumption of buying for railway purposes are reported. As with pig iron, prices of finished iron have maintained their steadiness during the past month, and there are no alterations to report.

The weak spots in the market for home-produced steels are the poor call for both shipbuilding and constructional materials. Of early improvement in either of these branches prospects are small. For a long time, also, the condition of the locomotive building industry has been far from satisfactory, although more recently a very slight improvement in the position of one or two firms has been reflected in a somewhat better demand for boiler plates and other materials. In certain of the lighter steel branches, prospects are believed to be rather brighter, whilst in high-carbon and special alloy steels business at the present time, as it was during the closing months of last year, is on a better scale than it was previously. In the latter department the tendency of prices of late has been towards higher levels, but in almost every other section of the steel trade quotations have been about maintained at around the figures that were current a month ago.

Uncertainty as to tariff developments in connection with imported iron and steel products continues to have a restrictive effect on business in this section. Users generally are not venturing far ahead, and prices tend to become largely nominal, although selling competition is keen.

Birmingham's Industrial Activity.

The trade outlook in Birmingham is more encouraging than for some time past. Many firms are finding it necessary to work overtime, while others are increasing their staffs and extending their works in order to cope with a steady flow of orders. This satisfactory improvement applies to such diverse industries as light motor-cars and heavier commercial vehicles, electric furnaces, cutlery, wireless parts, including radio components, valves, and bakelite manufactures. The City of Birmingham Information Bureau states that within the last month an increase in the industrial power load of about 17,000 kw. has been recorded. A large area of land in Birmingham has recently been purchased with the object of developing it industrially along similar lines to that at Slough. Several firms from abroad have taken factories in the Birmingham area and are manufacturing goods which previously were not made in this country. The Information Bureau has received inquiries from nearly forty firms, all of which have announced their intention to manufacture in Great Britain. These have been received from France, Belgium, Holland, Germany, and America, and in some cases representatives of the firms have visited Birmingham and inspected the sites available. The Bureau has also recently got into touch with a large number of foreign manufacturers, who, in view of the change in the fiscal policy and the departure from the gold standard, will need to consider setting up a factory in England.

JOHN HOLROYD & CO. LTD.

In this firm's advertisement on page 20 they are described as makers of "Holfos" and "Surper Holfos" Bronzes; this, of course, should read makers of "Holfos" and "Super Holfos" Bronzes.

MARKET PRICES

ALUMINIUM.

99% Purity	£85 0 0

ANTIMONY.

English	£40 0 0
Chinese	28 5 0
Crude	22 0 0

BRASS.

Solid Drawn Tubes	lb.	10d.
Brazed Tubes	lb.	12d.
Rods Drawn	,,	9d.
Wire	,,	8½d.
*Extruded Brass Bars	,,	4⅜d.

COPPER.

Standard Cash		£39 7 6
Electrolytic		47 0 0
Best Selected		39 15 0
Tough		39 10 0
Sheets		75 0 0
Wire Bars		50 0 0
Ingot Bars		50 0 0
Solid Drawn Tubes	lb.	11¼d.
Brazed Tubes	,,	11¼d.

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0 1 11½ Plus 20%
‡Ferro Tungsten	,,	0 1 8½ Plus 20%
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.		
NOMINAL: 2-4% Carbon, scale 12/- per unit	ton	33 2 6
4-6% Carbon, scale 8/- per unit	,,	24 0 0
6-8% Carbon, scale 8/- per unit	,,	23 0 0
8-10% Carbon, scale 8/- per unit	,,	22 10 0
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steel-work. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/6 per unit	,,	36 0 0
Guar. max. 1% Carbon, scale 15/- per unit	,,	39 17 6
§Guar. max. 0.7% Carbon, scale 15/- per unit	,,	40 10 0
‡Manganese Metal 96-98% Mn.	lb.	0 1 6
‡Metallic Chromium	,,	0 2 9
§Ferro-Vanadium 25-50%	,,	0 12 8
§Spiegel, 18-20%	ton	6 17 6
Ferro Silicon—		
Basis 10%, scale 3/- per unit	ton	5 17 6
20/30% basis 25%, scale 3/6 per unit	,,	7 12 6
45/50% basis 45%, scale 5/- per unit	,,	10 17 6
70/80% basis 75%, scale 7/- per unit	,,	16 8 6
90/95% basis 90%, scale 10/- per unit	,,	23 0 0
§Silico Manganese 65/75% Mn., basis 65% Mn.	,,	12 7 6
§Ferro-Carbon Titanium, 15/18% Ti	lb.	0 0 6
Ferro Phosphorus, 20-25%	ton	17 10 0

FUELS.

Foundry Coke—	
S. Wales	£1 2 6 to 1 5 0
Sheffield Export	0 14 0 to 0 15 0
Durham	15 0
Furnace Coke—	
Sheffield	0 14 0 to 0 15 0
S. Wales	0 17 6 to 0 18 0
Durham	0 14 6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)		£53 0 0
*Commercial Ingots		45 0 0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0 0 9
*Cored Bars	,,	0 0 11

LEAD.

Soft Foreign	£17 7 6
English	16 15 0

MANUFACTURED IRON.

Scotland—	
Crown Bars, Best	£10 5 0
N.E. Coast—	
Rivets	11 0 0
Best Bars	10 10 0
Common Bars	10 0 0
Lancashire—	
Crown Bars	9 15 0
Hoops	£10 10 0 to 12 0 0
Midlands—	
Crown Bars	£9 15 0 to 10 0 0
Marked Bars	12 0 0
Unmarked Bars	—
Nut and Bolt Bars	£8 7 6 to 8 12 6
Gas Strip	10 12 6
S. Yorks.—	
Best Bars	10 15 0
Hoops..Hoops	£10 10 0 to 12 0 0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	9d.
*Cored Bars	,,	11d.
†Strip	,,	11d.
†Sheet to 10 W.G.	,,	11½d.
†Wire	,,	13⅛d.
†Rods	,,	11½d.
†Tubes	,,	1/5
†Castings	,,	1/1¼

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—	
Hematite M/Nos.	£3 8 6
Foundry No. 1	3 12 0
,, No. 3	3 9 6
N.E. Coast—	
Hematite No. 1	3 5 6
Foundry No. 1	3 1 0
,, No. 3	2 18 6
,, No. 4	2 17 6
Cleveland—	
Foundry No. 3	2 18 6
,, No. 4	2 17 6
Silicon Iron	3 1 0
Forge No. 4	2 17 0
N.W. Coast—	
Hematite	3 14 6
Midlands—	
N. Staffs Forge No. 4	3 1 0
,, Foundry No. 3	3 6 0
Northants—	
Forge No. 4	2 17 6
Foundry No. 3	3 2 6
Derbyshire Forge	3 1 0
,, Foundry No. 3	3 6 0
West Coast Hematite	4 3 6
East ,, ,,	3 5 6

SWEDISH CHARCOAL IRON AND STEEL.

Pig Iron	£6 0 0 to £7 0 0
Bars, hammered, basis	£16 10 0 ,, £17 10 0
Blooms	£10 0 0 ,, £12 0 0
Keg steel	£32 0 0 ,, £33 0 0
Faggot steel	£18 0 0 ,, £24 0 0

All per English ton, f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£30 0 0
,, Braziery	27 0 0
,, Wire	—
Brass	22 0 0
Gun Metal	26 0 0
Zinc	7 0 0
Aluminium Cuttings	62 0 0
Lead	12 10 0
Heavy Steel—	
S. Wales	2 7 6
Scotland	2 2 6
Cleveland	2 2 6
Cast Iron—	
Lancashire	2 8 0
S. Wales	£2 7 6 to 2 8 6
Cleveland	£2 5 6 to 2 7 6
Steel Turnings—	
Cleveland	1 12 6
Lancashire	1 2 6
Cast Iron Borings—	
Cleveland	1 6 0
Scotland	1 12 0

SPELTER.

G.O.B. Official	—
Hard	£11 5 0
English	15 2 6
India	13 5 0
Re-melted	13 5 0

STEEL.

Ship, Bridge, and Tank Plates—	
Scotland	£8 15 0
North-East Coast	8 15 0
Midlands	8 17 6
Boiler Plates (Land), Scotland	10 10 0
,, ,, (Marine) ,,	10 10 0
,, ,, (Land), N.E. Coast	10 0 0
,, ,, (Marine) ,,	10 10 0
Angles, Scotland	8 7 6
,, North-East Coast	8 7 6
,, Midlands	8 7 6
Joists	8 15 0
Heavy Rails	8 10 0
Fishplates	12 0 0
Light Rails	£8 10 0 to 8 15 0
Sheffield—	
Siemens Acid Billets	9 2 6
Hard Basic	£8 2 6 and 8 12 6
Medium Basic	£6 12 6 and 7 2 6
Soft Basic	6 0 0
Hoops	£9 10 0 to 9 15 0
Manchester—	
Hoops	£9 0 0 to 10 0 0
Scotland, Sheets 20 W.G.	9 10 0

HIGH SPEED TOOL STEEL.

Finished Bars 18% Tungsten	lb.	2/9
Extras		
Round and Squares, ½ in. to ¼ in.	,,	3d.
Under ¼ in. to 3/16 in.	,,	1/-
Round and Squares 3 in.	,,	4d.
Flats under 1 in. × ⅜ in.	,,	3d.
,, ,, ½ in. × ¼ in.	,,	1/-

TIN.

Standard Cash	£140 10 0
English	142 0 0
Australian	141 15 0
Eastern	146 2 6
Tin Plates I.C. 20 × 14 box	13/6 to 13/9
Block Tin Cash	£138 7 6

ZINC.

English Sheets	£24 10 0
Rods	32 0 0
Battery Plates	20 5 0

* McKechnie Brothers, Ltd., quoted Jan. 11. † C. Clifford & Son, Ltd., quoted Jan. 11. ‡ Murex Limited, quoted Jan. 11.

Subject to Market fluctuations, Buyers are advised to send inquiries for current prices.

Prices quoted Jan. 11, ex warehouse.